VOLUME 59 [W. B. No. 1058] NUMBER 9

MONTHLY WEATHER REVIEW

SEPTEMBER, 1931

CONTENTS

UNITED STATES DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
WASHINGTON, D. C.

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - - - - - - - - - - - See page 4 of cover for prices

MONTHLY WEATHER REVIEW

Editor, ALFRED J. HENRY

VOL. 59, No. 9
W. B. No. 1058

SEPTEMBER, 1931

CLOSED NOVEMBER 3, 1931
ISSUED DECEMBER 9, 1931

A SUMMER CRUISE IN THE WEST INDIES

By R. DEC. WARD

[Harvard University, Cambridge, Mass., August 14, 1931]

INTRODUCTION

Need of rest, and a renewed interest in the West Indian region because of the preparation (in collaboration with Prof. Charles F. Brooks) of the chapter on the climatology of the West Indies for the new Köppen-Geiger *Handbuch der Klimatologie*, were the reasons for taking a month's cruise to the Lesser Antilles during the summer of 1931.

The instrumental equipment was purposely reduced to a minimum—a pair of traveling pocket dry and wet bulb thermometers and a small-size Richard barograph. This latter instrument went with the writer around South America in 1897–98, on the International Ice Patrol in 1923, and around the world by sea in 1929. In addition, copies of the latest United States Hydrographic Office Pilot Charts of the North Atlantic and of the Central American waters were also taken. No attempt was made to take regular observations at fixed hours. The thermometers were read and record of wind, cloudiness, etc., was made, when and as such observations were convenient and seemed desirable.

As it was my desire to visit some of the smaller and less well-known islands, one of the Canadian national steamships of the "Lady" class, assigned to the so-called eastern route, was chosen as best and most conveniently fulfilling the requirements. The regular schedule includes calls at Bermuda, St. Kitts, Nevis, Antigua, Montserrat, Dominica, St. Lucia, Barbados, St. Vincent, Grenada, and Trinidad, with the terminal port at Georgetown (Demarara), British Guiana. The same ports, in the reverse order, are touched on the return voyage. The round trip takes one month.

GENERAL GEOGRAPHY

The islands comprising the West Indian archipelago form a natural breakwater on the eastern border of the Caribbean Sea and the Gulf of Mexico, reaching from latitude 10° No. (Trinidad) to somewhat beyond the Tropic of Cancer (Bahamas). As a whole, these islands form a more or less regular arc or parabola, stretching from Yucatan and Florida to the coast of Venezuela. The Greater Antilles—Cuba, Haiti, and Santo Domingo, Jamaica, and Porto Rico—extend eastward from off Yucatan. The Lesser Antilles extend from east of Porto Rico to the Orinoco Delta in a sweeping curve slightly convex to the east. Trinidad, the southernmost of this group, is really a detached portion of the South American Continent.

The West Indies include an immense number of islands and islets, ranging in size from the larger ones with mountains of considerable elevation and elevated plateaus to the smallest rocks and keys which hardly rise above the surface of the sea. The islands differ from one another, not only in size but also in detailed physical characteristics and in population. The highest mountains are in the northern islands, while the volcanoes, whether active or dormant, are in the Lesser Antilles. With the exception of the Bahamas, the large majority of the islands are mountainous. Several are distinctly rugged. The western or interior zone of the Lesser Antilles is volcanic. The outer zone from the Bahamas to Barbadoes, is limestone. In Guadeloupe, which is volcanic in the west and limestone in the east, the two formations converge. The soils of the volcanic islands are wonderfully fertile and support luxuriant vegetation. The limestone islands, whose soils are generally less fertile, are regarded as "healthier" and are obviously subject to fewer dangers.

The use of the names Windward and Leeward for two divisions of the Lesser Antilles group is of interest to the climatologist. These terms are naturally associated with the steadiness of the trade winds, just as many other geographical designations had their origin in meteorological or climatic characteristics. The application of the term Leeward to the northern members of the Lesser Antilles, and Windward to the southern islands would seem to be illogical and inappropriate. The more northerly islands are certainly farther to windward if the normal direction of the northeast trade is considered to be the controlling factor. On the other hand, as the prevailing direction of the trades is more or less easterly throughout much of the year over most of the islands, it would perhaps seem more logical to call the easternmost islands Windward and those to the west Leeward. As a matter of fact, the name Windward recalls the track followed to the Spanish Main in the old sailing ship days, and the real Leeward Islands are those off the north coast of South America. In the new Oxford Advanced Atlas (Bartholomew), while the names Leeward and Windward are shown for the northern and southern islands of the Lesser Antilles, respectively, the islands off the Venezuelan coast are designated "Leeward Islands (of the Spanish)." Officially, the British Leeward Islands include those between the Virgins and Dominica, and the Windward Islands extend from St. Lucia to the south.

HISTORY

Historically the West Indies region is full of interest, of romance, and of thrilling tales of the old pirate and buccaneer days. Columbus, on his first and most

famous voyage, reached the Bahamas (1492), and on his later voyages discovered most of the larger islands. The name West Indies perpetuates the original conviction of Columbus that he had discovered a western route to India, and the name Antilles recalls the fact that he was thought to have reached the fabled land of Antillia. Spain naturally claimed the whole archipelago, but she was not allowed to remain in undisputed possession. British and Dutch sailors were before long cruising in the West Indian waters. Spain began to lose ground, and toward the end of the seventeenth century relinquished her claim to exclusive possession. As the power of Spain declined, other nations gained foothold, notably the English, French, and Dutch, and later the United States. Political changes have been frequent, and are rather hopelessly confusing, many of the islands having changed hands more than once. Porto Rico became a United States possession after the war with Spain, and St. Thomas was later purchased by the United States from Denmark. These changes are, however, of comparatively little concern to the casual traveler, who is mainly interested in sailing over the tropical seas, in enjoying the charms of the tropical vegetation, and in visiting new scenes.

The earliest conquerors expected to find great wealth of precious metals in the islands, but in this hope they were disappointed. The abundance of gold and silver came from the mainland to the west, and the dispatch of treasure-laden ships to Spain naturally served as an irresistible attraction to pirates and buccaneers. Many names of the early navigators became famous in history, e. g., Sir Francis Drake and Sir John Hawkins, who came to the West Indies as privateers and died there. Other names also associated with these islands are Sir Walter Raleigh, Lord Nelson, Rodney Hood, Benbow, and others. Raleigh made his famous expedition to the Orinoco from the island of Trinidad. The Spanish Main was long infested by pirates and marauders—British, Dutch, and French. Legitimate trade suffered. Ordinary commerce could only be carried on under conditions of extreme danger and difficulty and by force of arms. Piracy finally became a decreasing menace in the earlier years of the eighteenth century, but it persisted, more or less sporadically, along the coasts as late as the early part of the nineteenth century.

The wealth of the West Indies has been in their agricultural resources, not in the output of precious metals. The extended and systematic cultivation of sugar-cane, from about the middle of the seventeenth century, marked the beginning of the prosperity of the islands, and was made possible by the introduction of African negro slave labor. From an economic point of view, slave labor was a success. In the slave traffic all the nations having possessions in the West Indies took part. The cessation of the traffic in slaves; the emancipation of the slaves; competition with European beet sugar whose production dated from the Napoleonic wars and was encouraged by bounties, and other political and economic factors, combined to bring about a gradual decline of West Indian prosperity in the nineteenth century. Labor became scarcer, more expensive, and less reliable. Fortunes were lost, and a long period of depression set in. More recently, with the introduction of other staple crops, diversified agriculture, and improved methods of cultivation, the general conditions have somewhat improved. Nevertheless, as is well known, tariff laws and regulations of other countries, and numerous political changes and upheavals of more recent days, have been serious handicaps in the development of sound and stable prosperity in these islands.

POPULATION

Chiefly because of the introduction of negro and other labor, the population of the West Indies has become very mixed. The great bulk of the people are still of pure African blood. European-negro mixture comes next; and there are also coolies from India, Chinese, and a very few aboriginal Carib Indians. The whites play the most important part in the administrative and commercial life of the archipelago, but are very distinctly in the minority.

CLIMATE

The larger climatic characteristics of the West Indian region are easily summarized. They are very simple and very uniform.[1] The climate is typically tropical, with great uniformity of temperature, and with normal modifications resulting from latitudinal, topographic, and insular controls. With the exception of the Greater Antilles, the islands are small and therefore the land effects are generally subordinate to those of the water. Near sea level over most of the area, the mean annual temperatures are between 77° and slightly over 80°; the means for the coolest month are mostly between a little over 70° and somewhat under 80°; those for the warmest month between 80° and a few degrees above 80°. The Lesser Antilles have mean annual (sea level) temperatures of 79° or thereabouts, running about 2° higher than those of the larger and more northerly and westerly islands of the Greater Antilles. The mean annual ranges are of the order of 3° to 5° in the southern islands and 10° or slightly more in the Bahamas and Cuba. In the Greater Antilles minima near sea level have mostly ranged between 50° and 60°; in the remaining islands, between 60° and 65° or slightly higher. The absolute maxima have run, in round numbers, between 90° and about 100°. In the mountainous islands relief from the heat of the lowlands may be found on the slopes and uplands, varying elevations providing a corresponding variety of climates.

The North Atlantic high-pressure belt lies to the north and northeast of the West Indies throughout the year. It has its greatest extent in summer, at which season there is a slight increase in pressures over the islands. The area lies well within the northeast trades and winds from northeast or east prevail, there being no noteworthy changes in direction. At many stations, and especially in the easternmost islands, the mean direction is fairly steadily easterly. With the advance of summer, east and southeast directions become more frequent, and the velocities are somewhat lower. Under favorable conditions of exposure and of topography, land and sea breezes are well developed in many places. On the windward sides of the islands the sea breeze increases the velocity of the on-shore trades during the daytime. Winds from the sea, whether normal trade or sea breeze or the two combined, help greatly to temper the heat on land. Gales rarely occur, the southern islands being especially free from them. Extreme velocities of 100 or more miles an hour have occurred during hurricanes.

Differences of rainfall rather than differences of temperature distinguish the seasons, this being a general characteristic of tropical climates. The rainfall is heavy, or at least abundant, nearly everywhere. The windward mountain slopes naturally have the largest amounts; the leeward slopes and the interiors are much drier. Under varying topographic controls, great contrasts

[1] For a detailed account, with numerous tables and a complete bibliography, see the sections on the West Indies, by R. DeC. Ward and Charles F. Brooks, in the new Köppen-Geiger *Handbuch der Klimatologie*. The numerical data given in the present paper are generalized.

are found within very short distances. In the Leeward Islands the mean annual rainfall is generally more than 45 inches; on most of the islands it is 80 inches or over; at the highest elevations it is more than 150 inches. In the Windward Islands it varies between a little over 40 inches to about 120 inches, several stations showing annual means well over the latter amount. The months of maximum and of minimum rainfall vary somewhat in different parts of the West Indies, as well as on the individual islands. The rainiest months are usually from June to November; the driest, from January to April. The pressures are then relatively high, and there is the greatest frequency of northerly winds. The rainy season is, in general, a double one, with maxima in May (June or July) and in October or November, corresponding to two periods of lower pressure. This is also the time of most active convection and of many thunderstorms. October, usually wetter than May, is the time of lowest pressure and of hurricane rains. As the trades are forced to ascend the mountains throughout the year, the windward slopes have rainfall in winter as well as in summer, especially at the greater elevations. The lee slopes and the interior portions of the mountainous islands have relatively dry winters. These receive the bulk of their rainfall in the warmer months, when convection is most active. The southern islands generally have their first maximum retarded to June, July, or even August, and the second to November. The general régime is therefore a drier season in late winter and spring, and a rainier season in summer and autumn.

Relative humidity averages between 70 per cent and 80 per cent, or even more. It is generally at its minimum in March or April, at the season of least rainfall, and at a maximum in the autumn, when the most rain falls. The air is naturally damper on the windward than on the leeward sides of the islands. Fog is practically unknown in the waters of the Spanish Main.

The only violent weather phenomenon is the hurricane. In late summer and autumn, toward the end of the rainy season, and much less often in early or midsummer, violent tropical cyclones occasionally visit portions of the West Indies group. They are most frequent in the northern islands. The most violent ones may cause a heavy loss of life, and do great damage to buildings and crops. In their season, they are a menace to navigation. The more southern islands are rarely visited by them.

The available date regarding thunderstorms are scattering and incomplete. From November to April there are very few such storms, and over the smaller islands they are practically unknown between January and April. May and June show a marked increase in frequency, with a maximum in July to September.

The winter will doubtless always be the popular season for northern tourists in the West Indies, yet climatically the "winter" and the "summer" are so much alike that there is but little to distinguish them from one another, at least in so far as the temperatures are concerned. This is especially true of the Lesser Antilles, and notably so of the southernmost islands. The "summers" are there practically the same as the "winters," although the absolute maximum temperatures run a little higher in the "high sun" season. The Greater Antilles, farther north and nearer the continent, have slightly more marked temperature differences between the seasons. During the winter months the minima are somewhat lower there than farther south, and occasional importations of greatly tempered "cool waves" from the continent reach these islands, as in the case of the "northers" of Cuba. On the mountain slopes of the well-known Greater Antilles the climate is naturally cooler and more invigorating, especially in winter, than in the case with the coasts of the southern islands of the Lesser Antilles. It is, however, a mistaken but very widespread popular notion that summer is a wholly impossible season for visiting the West Indies. The statement in a standard publication of recent date, that the heat increases in July "to an extent well-nigh unbearable" is misleading. The summer months are, it is true, generally more rainy than those of winter, and the occasional hurricanes of late summer and autumn are certainly somewhat repellent. Yet rain occurs more or less frequently in all months, and hurricanes are fortunately few, and usually far between. The desire to escape from cold, and snow, and ice, and rough weather will, however, always tempt northerners to crave the bright sunshine, blue seas, and balmy air of the Spanish Main in winter. The summer provides sufficient heat and pleasant outdoor conditions in the homeland. The great American trek in summer is northward to the mountains, seashore, and lakes, or eastward across the North Atlantic, not southward to the everlasting summer of the Tropics.

SUMMARY OF WEATHER CONDITIONS AT SEA JULY 9 TO AUGUST 6, 1931

The following notes were made from day to day during the cruise, and were written up at sea. No attempt has been made to consult reference books or to verify every statement.

I have often been asked what interest there can possibly be in traveling over seas and to lands whose weather conditions and climates are already well known, and have been described by previous writers. The answer is very simple. Between seeing a condition which is presented graphically on a chart or reading a description of it in print, and actually feeling and observing the same condition one's self, there is all the difference between the dead fact and the living reality; between a mere quotation and the vivid recollection of a personal experience. "Wandering in search of weather" is a fascinating pursuit, in which everyone who attempts to teach the science of the earth's atmosphere should engage whenever possible. Furthermore, weather types and climatic conditions, wherever met with, almost always present certain aspects which did not attract the attention of previous observers. Hence the thrill of possible discovery always stimulates the "weather hunter." On this particular voyage there was the added interest of visiting the places at which the longest and best series of meteorological records have been kept in the islands at which stops were made—records which, in connection with recent work on the climatology of the West Indies, proved of great value. Basseterre (St. Kitts), Charlestown (Nevis), St. Johns (Antigua), Plymouth (Montserrat), Roseau (Dominica), Castries (St. Lucia), Bridgetown (Barbados), Kingstown (St. Vincent), St. George (Grenada), Port of Spain (Trinidad), were all familiar names, as was Georgetown (British Guiana).

To give anything more than a very brief summary of the observations made on the trip would weary the reader and would serve no useful purpose, although taking these observations added greatly to the interest of the cruise.

A barograph is a most welcome companion on an ocean voyage, whether it be in the stormy belts of the prevailing westerlies or in the uniform pressure conditions of the trades or doldrums. That wonderful double

diurnal maximum and minimum, traced day after day with clocklike regularity in the Tropics, never ceases to have a fascination for me. My collection of barograph curves, traced during previous ocean voyages, contains many weeks' sheets showing this remarkably uniform diurnal variation. The story of the pressure record made by the barograph on the present trip is easily told. The highest point on the outward voyage was reached near Bermuda (30.2 inches, uncorrected). From the crest of the North Atlantic high there is a slow decrease toward the equatorial low-pressure belt to the south. This was clearly indicated on the barograph curve. A pressure of about 30 inches was reached near the central portion of the Lesser Antilles. From there to the north the readings were somewhat higher; to the south, somewhat lower. The diurnal variation, faintly perceptible about 2° to 3° south of Bermuda, was marked throughout the whole trip from about 28° N. to Demerara and back. The lowest readings were between 29.75 inches and 29.8 inches (uncorrected), in Demerara. Between Boston and Bermuda the winds on the outward voyage were southeast. Soon after leaving Bermuda, and throughout the whole voyage to British Guiana and back, the ship was in the northeast trades. The northern limit of these winds (about lat. 28° N. in July) was passed without any change in wind direction. In this western part of the North Atlantic in summer the trades blow prevailingly from points between east and south-southeast, as is consistent with the rotary anticyclonic outflow on the western side of the North Atlantic high. The winds south of the northern limits of the northeast trade were Northeast, East, or Southeast, mostly of force 3 or 4, occasionally with higher velocities during squalls. There were also a few days with very light breezes. The southern limits of the northeast trade in July (lat. 10° N.) are in the latitude of southern Trinidad, and the northern limits of the southeast trade are at about latitude 6° N., just off the coast of Dutch and French Guiana. The ship encountered no "equatorial calms" during her two crossings from trade belt to trade belt, nor was there any really normal doldrum weather. The winds remained light to fresh from easterly points, and the weather was fairly typical of the trades, with some squalls. It will be remembered that typical doldrum conditions are not, as a rule, characteristic of this part of the western North Atlantic, and that the chances of finding light winds and calms are considerably fewer here than in the equatorial low-pressure belt off the west coast of Africa.

Those who think that steaming in the trades is monotonous can have little appreciation of the ever-changing panorama of the clouds. There are those wonderfully bright days when the blue skies are dotted with typical trade cumuli, their tall columnar forms leaning over to leeward, their tops breaking off and drifting away, dissolving as they go, and being replaced by new tops. There are days when conditions favor more active cloud growth, when cumulo-nimbus is the characteristic cloud form, when the skies are darker, when there are brief showers accompanied by slight squall winds—almost typical doldrum conditions. There are also dull days, when the skies are gray, and one is reminded of overcast days at home; and there are days when the sky is clear from morning to night. Surely, the sea traveler with his eyes open should never complain of monotony in the trades. These variations in the types of clouds and in the amounts of cloudiness are puzzling, in view of the fact that the air temperatures, the relative humidities, and the wind direction and velocity observed on board ship do not vary appreciably on days of widely different cloud conditions. The explanation is doubtless to be found in varying conditions aloft. The writer has spent, in all, several weeks in the trades, in North and South Atlantic, North and South Pacific, and in the Indian Ocean, and he has never failed to find interest and variety in the ever-changing cloud forms. On this voyage he was again impressed by the growth of the trade cumulus and rudimentary cumulo-nimbus in the later afternoons and early evenings, often to the shower stage. These growing cloud tops, illuminated by the setting sun, are beautiful to watch. Increased convectional ascent as the sun goes down is doubtless due to radiation from the tops of the clouds themselves.

Temperature observations on board ship were made in the shade, in well-ventilated locations, by sling thermometer. They ranged, roughly, between 75° and 85° most of the time, rising very slowly toward the south, where the readings during the daytime and early evenings remained steadily about 83° to 85°. The relative humidity was high and the air on shore was distinctly of the "hot-house" type. Under such conditions, walking in the narrow streets, under the tropical sun, and out of the wind, was always extremely uncomfortable. On the other hand, relief could always be found on board the ship, even when she was at anchor, because of the light or fresh breeze which was practically always present. The maximum observed on board was 86.5°. The official maximum on land was 90.2° (Bermuda). The most uncomfortable conditions on board ship were felt when the anchorage was close inshore, in the lee of hills that cut off the refreshing trade winds. Forced ventilation was used during the whole trip, and in addition electric fans were in constant operation in staterooms.

There were no gales; there was no fog after leaving the Massachusetts coast; there were no hurricanes. Those who dread the storms, gales, fogs, rough seas, and changeable weather of the much-traveled northern North Atlantic will find the poetry and charm of the ocean in the uniformity of temperature, bright skies, smooth fogless seas, and gentle trade winds of the Tropics. The complete meterological ignorance of the average passenger was illustrated time and again by such remarks as "how lucky we are to have such a fine breeze"; or "it is fortunate that the sea is so smooth"; or "I hope we shall have no fog".

BERMUDA

The Bermudas are in reality a modified coral atoll, resting on a submarine mountain. These coral islands lie farther north than any others of similar origin, a fact due to their position in the warm waters of the Gulf Stream eddy.

> By the gay borders of Bermuda's isles
> Where spring with everlasting verdure smiles.

So runs the poet's climatic summary. The mild and equable climate, accessibility, extensive advertising, and other factors, have combined to make Bermuda an increasingly popular winter resort. The winter months are and will remain the most alluring season; the summer, so far as maximum temperatures are concerned, is not as hot as are our own hot waves, but the cool spells brought by our summer "cool waves" and by our cyclonic onshore easterly winds along the Atlantic coast are wholly lacking. The marine type of retarded maximum and minimum temperatures is clearly indicated. August is the warmest month (mean slightly over 80°) and February or March the coolest (a few degrees over 60°). In an average winter the thermometer does not fall below 40°,

and is oftener near 60° than 40°. In summer, the maxima are oftener below than above 90°. Frost and snow form no part of the picture.

The Bermudas lie throughout the year in the western portion of the North Atlantic anticyclone. The mean wind direction is southwest, somewhat more northerly in winter and more southerly in summer. The winter winds are tempered by the warm waters over which they blow. On the other hand, the prevailing wind of summer imports high temperatures which one writer has described as "oppressive heat" between July and October, especially in August, and as resembling a "vapor bath". People who have lived for years in the fresh trade winds of the West Indies report Bermuda as seeming much the warmer and more enervating, especially at night. Bermudians, however, maintain, and rightly so, that they have a more equable summer climate, with less high maxima, than is found over much of the United States.

Occasional hurricane winds, and not infrequent winter gales, are irregular visitors. The rainfall is moderate. Hamilton has slightly over 50 inches, with maxima in January and April. There is greater probability of rain in winter, when extra-tropical cyclonic storms reach the islands, and less in early summer. The main source of water is rain caught in cisterns. During the past winter, water was brought from the United States to supply the needs of the winter visitors. The relative humidity remains between 70 per cent and 80 per cent throughout the year.

The vegetation of Bermuda is less characteristically tropical than that of the Antilles. The rainfall is less and the winters are cooler. Many tropical fruits and economic plants are, however, successfully cultivated. Bermuda is famous in the United States for its early vegetables, especially potatoes, its onions, and its Easter lilies.

The local weather reports for the two days preceding the writer's first visit showed clear to fair skies, maximum temperatures of 84° and 85°; minima of 75° and 76°. The temperatures of late afternoon and evening on board were 77.5° and 76.5°, respectively. The local newspaper reported: "There has been a strong southerly wind all of the past week, so that yachting and boating of all kinds in the Great Harbour has been difficult and unpleasant." On the second stop, the skies were cloudless, the wind light northerly, and the temperatures on board (8 a. m. to 1 p. m.) between 82° and 84°. The official record for August 3 was as follows: Maximum, 90.2°; minimum 74.2°; rain, 0.00 inches; barometer, 30.15 inches (a. m.) to 30.13 inches (p. m.); mean wind velocity, 17 miles an hour; sunshine, 9 hours, 20 minutes.

THE LESSER ANTILLES

The volcanic islands of the British Lesser Antilles all have certain common characteristics, and present much the same general appearance. They owe their picturesqueness, as well as their fertility, to their volcanic origin. Their mountains are sometimes symmetrical volcanic cones; sometimes rugged peaks and sharp serrated ridges; sometimes only gently rolling hills. There is usually one dominating volcanic summit, like Mount Misery on St. Kitts, the Soufriére on Montserrat, the Morne Diablotin on Dominica, again a Soufrière on St. Vincent, rising to between 3,500 and somewhat over 5,000 feet above sea level. Dense forests cover the slopes and reach up to the tops of most of the mountains, while over the lower slopes and in the fertile valleys stretch the cultivated fields, with their pleasing variety of different shades of green, broken here and there by the dark rich soil of freshly-tilled patches awaiting the next crops and by picturesque coconut, mango, and banana groves. Very beautiful everywhere are the brilliant colors of the many tropical flowers, notably poinsettia, hibiscus, bougainvillea, royal poinciana, and lilies of various sorts. Only a small portion of any of the islands is cultivated.

Climatically, all the islands are essentially alike, as has been indicated in the introductory summary. All have wetter windward and drier leeward sides. All have cloud caps and cloud banners over their higher mountain tops. All show typical diurnal-cumulus cloud development, and, especially in the afternoon and evening, have local showers from their massive cumulo-nimbus clouds. All have essentially the same vegetation and agricultural products. In all of them the capital and chief port is on the leeward side, where the water is smooth. From a shipping point of view the advantage of such a location is obvious. The disadvantage is that the velocity and steadiness of the trades are considerably decreased, and the feeling of heat is greater.

In size the various islands visited range from 30 to 300 square miles in area. Some of them are so close together that two were visited on the same day, with a stop of several hours at each island. Taking the Lesser Antilles in sequence from north to south they average only about 30 miles apart.

The early prosperity of the West Indies was built on sugar, cultivated by slave labor. After the abolition of slavery, with a large negro population no longer compelled to do hard work, a distinct decline began. Further, the present depression in the sugar market, resulting from overproduction of cane and beet sugar, has had most unfortunate economic consequences in the West Indies. In fact, it is probably no exaggeration to say that the large majority, if not all, of the islands are in a state of stagnation, if not of still progressive decay. Sugar, molasses, and rum still lead the list of agricultural products in most of the islands visited. Coconuts, coconut oil and copra, cocoa, limes, bay rum, arrowroot, mangoes, bananas, bread fruit, sweet potatoes, Indian corn, spices, etc., are also characteristic products. The islands differ considerably in their individual products, and details concerning the special products of each island would be wearisome and of no value in the present article. The cargo picked up by the ship at the different ports and landed at other ports, showed clearly that the products are not all alike. It was noticeable that the Demarara rice was brought north to several of the islands, and that mangoes, limes, avocado pears, and coconuts were shipped to Barbados, Bermuda, and Canada. The efforts now being made throughout the islands to find new crops and other substitutes for sugarcane are almost pathetic. On one island the development of a livestock industry, in another the raising of vegetables for the Canadian winter market, in another the planting of cocoa, in another the cultivation of citrus fruits—these are more or less random illustrations of hopes which are held for future success. The government agricultural departments are doing their part in experimental work with various plants and crops, as may be seen on a small scale in the botanical gardens in Dominica, St. Lucia, and St. Vincent. The experiment-station work in Barbados and Trinidad and in Georgetown (British Guiana) has already accomplished important results, and is full of promise for the future. Small wonder is it that the British West Indies are very seriously agitating federation, accompanied by complete dominion status, and that every effort is being made to cultivate reciprocal trade relations with Canada. The regular service maintained by the Canadian National

Steamships is striking evidence of the increasing closeness of these relations with Canada. Every automobile seen in the islands was "made in Canada."

St. Kitts, the first of the Leeward Islands visited on the voyage south, is the oldest British settlement in the West Indies. From Basseterre, its chief town, there is a good series of meteorological records. Of St. Kitts one writer has said: "The bracing qualities of the atmosphere are portrayed in the general good health of the inhabitants. The mornings and evenings of the hottest days are agreeably cool." Yet another has said: "Basseterre is not the most healthful (place) in the islands, but from November to May or June it is safe to live in." Very beautiful were the cumulus clouds on Mount Misery, forming and dissolving in the fesh trade winds, and very easy was it to determine the prevailing wind direction by means of the rows of windblown coconut palms in exposed locations.

Nevis has a name of meteorological origin, wrongly applied. Columbus named it Nieve in 1493 because of the white clouds which he saw enveloping its highest mountain, a cloud cap the same in appearance to-day as it was when Columbus first saw it. Nevis, once the social center of the West Indies, the birthplace of Alexander Hamilton, and the island on which Lord Nelson was married, is to-day a mere economic ghost of its former self. There is a vivid recollection of a drive around Nevis on a brilliant afternoon; of the marked difference between the vegetation and general condition of the population on the leeward and windward sides; of abandoned sugar mills and shacks on formerly prosperous estates; of ancient stone windmills now falling to ruins; of the smoke from dry cotton plants burned after the harvest; of the fires of the charcoal burners on the mountain. That Nevis is within the hurricane belt was evidenced by the coconut palms lying prostrate as the result of the 1928 hurricane, and by the fact that the windmills still in use in harvest time had had their "sails" removed in anticipation of the coming hurricane season.

Antigua the seat of government of the British Leeward Islands colony, has less elevation than the other volcanic islands, and this fact is inevitably reflected in the relatively small rainfall. The maximum altitude in the Shackerley Mountains is 1,500 feet. A pleasing variety of rolling hills and cultivated valleys is the feature that strikes the tourist as his ship enters the open roadstead of St. Johns and anchors 2 or 3 miles offshore. The excursion to English Harbor is full of historical interest. Here Nelson and Rodney careened and refitted their ships. Here may be seen the old dockyards, barracks, shipbuilding sheds, cannon, anchors and anchor chains, ships' figureheads, and other naval relics of olden days. The drive to English Harbor also gives an excellent cross section of the agricultural activities of the people.

W. H. Alexander has written of Antigua:

> Owing to a light rainfall, the elevated portions of the island are not clothed with the luxuriant tropical vegetation to be seen in other of the Leeward Islands, such as St. Kitts, Montserrat, and Dominica, but presents to the eye a rather desolate, uninviting appearance, The valleys, however, stand in marked contrast to the hills, being arrayed in all the beauty and vernal richness of a tropical climate. There are no rivers, and but few springs, and these are brackish. The people are dependent upon rainfall for a water supply, and have in former times suffered great loss and inconvenience from droughts.

The lack of any considerable elevations which would force the trade winds to climb higher, and thus cause more condensation, is the obvious reason for the relative dryness. One of the picture post cards on sale in St. Johns shows government officials supervising the rationing of water in a native village during a drought. On the other hand, another writer says:

> Antigua is so generally spoken of as a dry-as-dust place, where the earth refuses to yield water for the use of man, that I received more than ordinary pleasure in gazing on the wooded hills and green vales which decorate the interior of the island. (H. Coleridge: "Six Months in the West Indies in 1925.")

The historical records of Antigua mention damage by hurricane winds at none too infrequent intervals.

On Montserrat the traveler, especially one in search of climatic responses, should take the motor drive from Plymouth across to the windward coast. In some respects there are similar contrasts to those seen on the famous Pali drive from Honolulu, but the latter is far more beautiful and impressive. Ascending by a good motor road from Plymouth, the terraced hillsides show intensive and effective cultivation. Cotton, grown even well up on the lower slopes, and Indian corn are here the chief crops. Breadfruit, sweetpotatoes, and cassava are also seen. At the highest point on the road, where there is a beautiful view over the ocean to the east, the trades are found blowing with added velocity, and the great dark rolls of cumulus and cumulo-nimbus clouds on the windward slopes and on the tops of the mountains are beautiful illustrations of the effects of the forced ascent of the trades. "Montserrat lime juice" was formerly the chief product of the island, and is still widely known, but of late years the lime-fruit industry has fallen off.

Wonderfully beautiful were the great masses of cumulo-nimbus clouds towering above the mountains of Dominica as the ship neared that island in the early morning, the tops of the clouds brilliantly illuminated by the rising sun, while below, in shadow, the dark gray and purplish colors stood out in marked contrast. The elevation of Dominica insures abundant rainfall. There are said to be 365 rivers on the island. Many old plantations formerly devoted to sugarcane are now being planted with limes, coco, and spices. The exports from Roseau on the day preceding the arrival of the *Lady Hawkins*, as reported by the customhouse, were cocoa, copra, ginger, bay oil, and fruit. Hurricane winds have been responsible for great damage to the trees, coconut palms in particular. C. W. Bellamy has written:

> The relaxing, enervating moisture of the air, the scorching, blazing heat of the sky, or the parching drought of the winds * * * are alike unknown in Dominica. * * * Hot days in the height of the summer season are only to be expected in these latitudes.

To the truth of the latter sentence the casual traveler who walks through the narrow streets of Roseau on a bright July day will certainly testify. In the local newspaper there were advertisements of hurricane insurance, and, "for the hurricane season," hurricane lanterns. A letter to the editor, referring to the government notices regarding hurricane precautions and hurricane relief measures, expressed regret that so much publicity was being given to this subject because of the unfortunate reaction in the minds of those who might be thinking of settling in the island.

St. Lucia is the largest and most northerly of the British Windward Islands. Castries, the chief town, lies on a deep and well-protected harbor, one of the finest in the West Indies. It was formerly a very important coaling station, but has lost its commanding position since the opening of the Panama Canal and the advent of oil-burning steamers. It is picturesque, but dead. Its few white inhabitants fly to the cooler hill slopes at night. From the wireless station, 800 feet above Castries, with its abandoned barracks, occupied by Canadian troops during the World War, a beautiful view of the island is obtained, including some prosperous and well-kept cane fields. As far back as 1650 tobacco,

ginger, and cotton were raised here, later to be replaced by sugarcane and coco. "Among all these beautiful islands," wrote Kingsley in "At Last," "St. Lucia is, I think, the most beautiful."

The most easterly of the West Indies is the low coral limestone island of Barbados, "the land of abiding sunshine," exposed to the full force of the northeast trades, famous for its remarkably equable and healthful climate. In contrast with the volcanic islands, the maximum elevation in Barbados is under 1,200 feet. Early devoted to sugar cultivation, the English planters of "Little England" developed large sugar estates and made fortunes. And Barbados, although it has suffered financially from the depression in the sugar market, has managed to remain more prosperous than many of its sister islands. Ninety per cent of the land under cultivation at the present time is devoted to sugarcane, but during the past few years there has been increasing planting of vegetables (tomatoes, potatoes, carrots) for the Canadian market. The fact that there is little or no individual ownership of land by peasant proprietors has forced the negro laborer to be dependent for his livelihood on work provided on the large estates. Where the West Indian negro has his own field to cultivate, he manages to survive with a minimum amount of labor.

Bridgetown lies on the shore of an open roadstead (Carlisle Bay) on the southwest of the island. It has always been a crossroads for marine traffic. Here Washington, with his brother Lawrence, stayed in 1751. Well known in the history of meteorological observations are the rainfall records, kept several decades past, at numerous stations in Barbados. These observations were undertaken in connection with the cultivation of sugarcane, and Governor Rawson's discussion of them in making forecasts of the sugar crop became a meteorological classic. A stay of several hours in the harbor of Bridgetown gave an opportunity, not provided on two previous visits to Barbados (1908, 1910), of taking a motor ride of many miles through the wonderfully cultivated country districts, of which the tourist who spends his time shopping in the city or bathing at the Aquatic Club has no conception. Sugar has long been king in Barbados, and in spite of the depression now existing in the sugar market still holds almost undisputed sway in the island. It was a typical Barbados day, with fleecy cumulus clouds traveling rapidly in the wind, with several short but heavy tropical showers to give variety to the scene, and with the soft trade blowing steadily. For mile after mile there were fields of sugarcane, waving in the wind, dotted with sugar factories and native villages, and here and there one of the original planters' country estates, inclosed by high stone walls, and surrounded by groves of mahogany, coconut palms, mangoes, bananas, breadfruit, all enlivened by the brilliant colors of hibiscus, bougainvillea and other tropical flowers. Very picturesque are the old stone towers of the windmills of earlier days, testifying to the importance of the strong and steady trades, and now unfortunately replaced by buildings containing modern machinery run by steam power. Indian corn, sweetpotatoes, cassava, yams, and other crops gave a pleasing variety to the scene, and from the occasional slight elevations wonderful views of the ocean, and of the trade surf rolling in on the windward coasts, combined to make a picture not easily forgotten.

Barbados is so low an island that the trades sweep across it with hardly an obstruction and with scarcely diminished velocity. Every tree of any height at all is wind blown, and every variety of distortion of trunk and branches and crown may be seen. The traveler on the deck of his steamer in Carlisle Bay may well rejoice that Barbados is flat, for across the bay at all times the strong trade wind brings refreshing relief after the hot streets of Bridgetown. Temperatures taken on board ship, at various hours during the day, varied only from 81.5° to 84°. On the return voyage at Barbados the temperature on board ship was below 85°, and the radio news reported a hot wave with a maximum of 97° in Boston.

St. Vincent has been described as one of the loveliest and least known of the Lesser Antilles. Its volcano, Soufrière, in the eruption of 1902, caused the loss of over 2,000 lives. Another famous historical eruption occurred about a century earlier (1812). Ashes from St. Vincent fell on Barbados, about 100 miles to windward, not, as a well-known West Indies guidebook explains the phenomenon, because of the terrific nature of the explosion, which drove the débris against the trades. At Kingston, the capital and chief port, the mean annual range of temperature is only 3.5°. The botanical garden, small but well cared for, claims to be the first of its kind established in the Americas for the propagation of plants "useful in medicine and profitable as articles of commerce, and where nurseries of the valuable productions of Asia and other distant parts might be formed for the benefit of His Majesty's colonies." Breadfruit, introduced in 1793, has prospered greatly. Cloves were brought from Martinique in 1787 and nutmegs from Cayenne in 1809. The tourist who sees only the port of Kingstown and the charming view of the wooded hills and cultivated fields from Fort Charlotte would never suspect the presence of volcanic activity as recent as that of 1902. The fact that the rainy season was beginning was emphasized by overcast skies and frequent showers. The maximum temperature on shipboard was 83.5°.

Grenada, the last and southernmost of the volcanic Caribbees (lat. 12° N.), has been called "the Spice Island of the West." Cocoa and spices here replace sugar, and fresh fruits and vegetables are shipped to Barbados and Trinidad. The Grenadians boast of the fact that Trinidadians come to Grenada in search of a cooler climate than their own. St. George, with its steep and narrow streets, sometimes terminating in a flight of stone steps, recalls many Italian cities. The local newspaper contained two advertisements which were of interest. One read: "Be prepared for the rainy season," and recommended raincoats, mackintoshes, tweed overcoats, and galoshes. The other bore out the reputation of Grenada as the "spice island" in the notice: "Be sure to get the best value for your cocoa, nutmegs, and mace by selling to —— & Co. (Ltd.)."

TRINIDAD

Physically, Trinidad (1,750 square miles), belongs to South America. The two east-west mountain ranges which border it on its northern and southern margins are a continuation of the northern and southern ranges of Venezuela. These mountains almost inclose the Gulf of Paria, which separates Trinidad from the mainland. The narrow straits on the north and south are the famous Dragons Mouth and Serpents Mouth. Through the Dragons Mouth (an imposing gateway) Columbus sailed when he discovered Trinidad, and through that northern gateway steamers now pass on their way to and from Port of Spain, "the Queen City of the Antilles," situated on the gulf at the northwestern corner of the island. In these narrow straits the mountain ranges are submerged, leaving a navigable channel. As one writer has expressed it, here "the long attenuated finger of Venezuela points

to the British Colony." Seen from the ocean, or the Gulf of Paria, Trinidad does not differ much in general appearance from the other islands, although none of its mountains are as high as the higher volcanic peaks of the Lesser Antilles. Nor are the products of the soil different. Sugar, molasses, rum, cocoa, coconuts, copra, etc., are leading articles of export. The famous "Pitch Lake" at La Brea has been known from early days. Here Sir Walter Raleigh, in 1595, secured pitch for calking his ships, and here the buccaneers also calked their ships. This asphalt lake covers about 90 acres; and although enormous quantities of asphalt have been removed, there seem to be no signs of exhaustion. The trip to the Pitch Lake was easily made by automobile from San Fernando, where the steamer called for cargo (sugar). An excellent asphalt road takes the traveler through a large sugar plantation, groves of coconut palms, and tropical forests, interspersed with many picturesque, if squalid, collections of huts inhabited by East Indians. Before reaching La Brea an oil field is passed through, with the somewhat novel sight of oil derricks standing in a tropical jungle. The lake itself, with its gray surface covered here and there with pools of water, is disappointing. On the other hand, there is the interest of its immense value, of its inexhaustible supply of asphalt, of the well-kept grounds and buildings of the company, and of the endless chains of buckets which carry the barrels of asphalt directly onto the jetty and load them onto the waiting steamers. Heavy tropical showers fell at intervals and the "patchy" character of the rains could easily be noted by the succession of wet and of dry sections of the road. Under overcast sky, after a thunderstorm off San Fernando, the temperature fell to 80.5° from 85° (2 p. m.). The local newspaper reported that the La Brea district was swept by a severe rainstorm and that the entire Pitch Lake was under water.

Trinidad, about 10° north of the equator, inevitably has a truly tropical climate, moderated by the trades. Port of Spain has a mean annual temperature of about 77°. January (about 75°) is the coolest month, and May the warmest (about 79°). The highest temperatures come before the rainy season, as in a monsoon climate. Extremes at Port of Spain are 100.4° and 57.2°. Relative himidity is always high, over 80 per cent in the rainy and about 75 per cent in the dry season. The rainfall is heaviest (over 120 inches) to the east of the northern mountains, and least (under 60 inches) on the shores of the gulf, on the west. The "rainy season" comes between June and December, with a primary maximum from June to August and a secondary in November. No month is wholly dry. The trades are distinctly weakest in the rainy season; in the dry season of "winter" they blow with full strength all across the island. Where freely exposed to the trades, cocoa trees are protected by wind breaks.

An umbrella was doubly useful during the few hours spent ashore at Port of Spain as protection against a very hot sun and again during the sudden tropical showers which fell at intervals. A visit to the local Weather Bureau station on the roof of the building of the harbor constabulary gave opportunity to look over the daily records and the sheets of the self-recording instruments. At noon, the hour of the visit, the dry bulb in the shelter was 88°; the wind very light from northeast. On the previous day the official readings were: 7 a. m., dry 74°, wet 73°; 3 p. m., dry 87°, wet 80°; maximum, 88°; minimum, 71°. A wet-bulb reading of 80°, it may be noted in passing, has been set by one writer as the limit beyond which physical labor by the white race is impossible. On the return voyage the official readings at Port of Spain were as follows: 7 a. m., dry 72°, wet 71°, 3 p. m., dry 79°, wet 77°; maximum, 89°; minimum, 71°; bright sunshine, 5 hours 38 minutes; wind, northeast. The damp heat of "summer" is very trying, certainly to a northerner. The "winter" months are surely more bearable, because of a lower sun, stronger trades, and cooler nights. Respect for the sun is shown by the fact that automobiles are parked on one side of the street before noon and on the opposite side after noon, the parking side being the shady one. The botanical gardens are very fine and beautifully kept up. The varieties of trees and plants of economic value are surprisingly large. Indeed, one need not go to the primeval forests of Trinidad, so wonderfully described by Kingsley in At Last, to see examples of all the important native forest trees.

Sailing from Port of Spain in the late afternoon, the passage through the Dragons Mouth gave wonderful views of the Venezuelan mountains on the west and the Trinidad mountains on the east, covered with heavy cumulo-nimbus clouds. Later, the surf dashing against the rocky shores of the north coast of the island and the dark rain squalls moving across the hills showed clearly enough why the windward coasts are so deserted and why they are still so heavily forested. Here the trade wind, not man, is master.

DEMARARA (BRITISH GUIANA)

The casual traveler who spends a day or so in Georgetown (Demarara) can see nothing of the great hinterland of British Guiana, with its plateaus and mountains, its vast primeval forests with their variety and abundance of animal, bird, plant, and insect life, its open savannas, its great rivers, its cataracts and waterfalls, its wealth of diamonds and gold and other valuable minerals, and its famous Mount Roraima. The flat alluvial coastal lowland, a narrow strip only a few miles in width, "was once nothing more than a mangrove swamp in front and a sedgy morass behind." The Dutch, the first European owners of the country, reclaimed most of the low coastal belt by means of sea walls, dykes, and dams and laid it out in sugar and cotton plantations, crisscrossed by canals and drainage ditches. Cotton was long ago abandoned and sugar became king. This coast, reclaimed from the sea and the forest, is practically the only inhabited and cultivated part of British Guiana, "the Golden Crown of South America," where Sir Walter Raleigh sought his El Dorado.

Georgetown, or Demarara, lies on the right bank of the Demarara, at its mouth, and also has frontage on the ocean. Lying below sea level at high tide, it is protected by a massive sea wall and is drained by canals and sluices, pumped by steam. The houses are raised above the ground on stone, concrete, or wooden posts. For at least two hours before reaching port the ocean is discolored by the mud brought down by the numerous rivers supplied by the heavy rains. "Few countries on the surface of the globe," wrote Sir R. H. Schomburgk, "can be compared with Guiana for vigor and luxuriance of vegetation. A constant summer prevails, and the fertility of the soil, the humid climate, and a congenial temperature insure a succession of flowers and fruits; in a person accustomed to the sleep of nature in the northern regions, where vegetation is deprived of its greatest charms, the leafy crown and the fragrant blossoms can not but raise astonishment and admiration."

The hot, steamy atmosphere of the Guiana coast is not exactly a white man's climate. By means of inden-

tured East Indian coolie labor, a plan now abandoned, the cultivation of sugar cane was here brought to a high state of perfection and of financial profit. With the lack of forced labor and the depression in the sugar market, British Guiana is turning more and more to rice and other crops under the skillful and tactful guidance of the agricultural department.

Meteorological observations have been kept at Georgetown (lat. 6° 50′ N.; long. 58° 12′ W.) for many years, first at the observatory and later (since 1882) in the botanical garden. The mean annual temperature is between 79° and 80°, with an annual range of 2.3°. The mean maxima range between 83° and about 87°, according to the season, and the mean minima between 74.°7 and 75.7°. The absolute maximum is 91.9°; the absolute minimum, 68°. The rainfall is heavy (85 inches in round numbers), and there is a double rainy season, May-August and December-January, with a long "dry" season in September-October and a short "dry" season in February, occasionally in March or April. Calms and light variable winds are most frequent in the primary wet season, which is normal and obviously controlled by the equatorial rain belt. The "winter" rainy season is abnormal and puzzling and its explanation has been much debated. The prevailing winds in the "low-sun" season blow more steadily and more directly on shore (northeast trades). The mean monthly rainfalls in June and in December are 12 inches and 11.5 inches, respectively, and in September and October 2.75 inches and 2.36 inches, respectively. The fact that during so much of the year the wind is on-shore is a great boon to Georgetown. The number of rainy days is 23 to 24 in June, 20 in December, 16 to 17 in February and March. The relative humidity is always high (75 to 80 per cent). Hurricanes never occur and high winds are very rare.

When one thinks of the Guianas there inevitably come to mind the horrible stories of the excessively high death rates among the convicts in French Guiana. As some one has said, "French Guiana was conveniently endowed with an unhealthy climate," and another has written: "Perhaps it is its fatal climate which has won for French Guiana its chief fame as a convict settlement." It is true enough that the disease and death rates in all the Guianas have in the past been alarmingly high, but "the man behind the climate," in British and Dutch Guiana especially, is winning out by means of modern sanitary and medical precautions. So successful has been the fight that Knoch has recently written, "to-day life on the coast, from the standpoint of health, offers no special dangers." That the steady "hothouse" air and the heavy rainfall are very trying to white men there is no doubt, but with free exposure to the wind, protection against the sun, and reasonable precautions life is not precarious.

Two of the most profitable and interesting days of the trip were spent in Georgetown. Through the courtesy of the agricultural superintendent of British Guiana, Mr. Peterkin, the many activities of the department of agriculture were fully explained. About 60 acres in connection with the botanical gardens are devoted to the experimental cultivation of many varieties of rice and of other crops. Thoroughly up-to-date methods of the selection and treatment of the different crops are employed in laboratory and field. The remarkable herbarium of British Guiana plants was also visited, and a leisurely inspection of the meteorological station, now located in the botanical gardens, well repaid the trip to Demarara. Windvane and 4-cup anemometers, self-recording, are on the roof of the 2-story building which also houses the herbarium. The Richard barograph is on the ground floor, as is the thermograph, the latter in a window shelter. Outside, in an inclosed rectangle, are the various outdoor instruments; the thermometers, wet and dry, in a Stevenson screen; evaporation tank; soil thermometers; radiation thermometer; Campbell-Stokes sunshine recorder; black bulb in vacuo; ordinary 8-inch gage and a Negretti and Zambra hyetograph. The exposure is excellent. One of the two days in Georgetown brought several short, light showers, and one heavy rainfall of about 0.80 inch in an hour and a half, accompanied by a sharp squall. The second day was clear to fair without rain. The heat was intense, but was relieved whenever there was a breeze, and beginning about sunset there was enough cooling to be noticeable and refreshing. On the day of landing the official record was as follows: 6 a. m., 74°; noon, 85°; 6 p. m., 81.5°; midnight, 81.0° maximun, 87°; minimum, 73°; maximum in sun 148°; minimum temperature on grass, 72°; wind velocity, 8 a. m. to 6 p. m., 4.5 miles an hour; 6 p. m. to 8 a. m., 1.78 miles an hour; maximum velocity, 7.5 miles an hour; rainfall, 12:05–12:10 p. m., 0.17 inch. On the following day the incomplete record showed: 6 a. m., 77°; noon, 79°; maximum, 85°. These few data serve to show the general character of successive days near the close of the primary rainy season in Demarara. The only appreciable variation from day to day is in the amounts of rainfall.

The return voyage from Georgetown gave opportunity to renew acquaintance with the weather types and climatic controls noted on the outward voyage. From Georgetown to Bermuda the barograph curve rose very slowly, day after day, on the weak pressure gradients, the highest reading (about 30.10 inches uncorrected) being recorded at Bermuda. The diurnal variation continued to beyond latitude 30° N., and faded away in the Bermuda area. Near the northern limits of the northeast trade calms were encountered and continued to Bermuda. The percentages of calms in the "squares" south and east of Bermuda in July are fairly high (15 to 19 per cent), as is to be expected on the weak pressure gradients over that part of the ocean. The two days in the westerlies between Bermuda and Boston brought a characteristic "temperate" zone variety of weather: Variable winds, mostly southwesterly, the first westerly winds in a month; mostly overcast skies; an early morning thunderstorm; near the New England coast some fog, the first fog since leaving this same area on July 9. The temperature, which had remained steadily over 80° on board ship throughout the voyage, fell below that point with fresh northeast winds a day west of Bermuda. Martinique, passed at night on the outward voyage, was clearly seen on a bright afternoon on the homeward trip. Great cumulus masses covered the mountain tops and rolled down the leeward slopes. Not until the ship was to the north of the island could the "steam-smoke" column rising from the summit of Mont Pelee be clearly seen. The vertical height to which this column rose varied. The top of it was turned to the westward by the trades.

Addendum.—The foregoing account of my month's cruise among the Lesser Antilles hardly includes all that was found in the way of meteorological and geographical interest. It is my chief hope that what I have written may stimulate some of my fellow teachers to go "weather hunting" away from home.

THE GENESIS OF A TROPICAL CYCLONE

By FRANKLIN G. TINGLEY

Foreword, by Willis E. Hurd.—After Mr. Tingley's death there was found in his desk the substance of the following article. It was preeminently true of its writer that he exercised a great amount of caution in the preparation of any text out of the routine for publication, with characteristic gentleness and shyness preferring to withhold its appearance in type until his ground for statements was completely laid out, solid, and satisfactory. Originally intended for publication in the MONTHLY WEATHER REVIEW, in conjunction with some related notations and analyses prepared by L. T. Chapel, of the Hydrographic Office at Cristobal, the Genesis of a Tropical Cyclone was apparently in the main complete, though it required some rearrangements and amplifications. These changes have been undertaken sympathetically by the writer of this foreword, with the feeling and hope that they would not have been unacceptable to his former division chief, from whom, in connection with his own studies and writings, he had always received the most sympathetic and helpful consideration.

The locality and some of its meteorological features.—About the middle of October, 1926, a cyclone of great importance formed in the southwestern part of the Caribbean Sea, where that body of water extends southward to the Isthmus of Panama. This extension is in the form of a large embayment extending some 700 or 800 miles southwestward from the main body of the Caribbean and having at its southern extremity the Mosquito Gulf on the Central American side and the Gulf of Darien bordering on the South American mainland. This part of the Caribbean lies between the region of the northeast trade winds of the Atlantic and that of the south to southwest winds of the extreme southeastern North Pacific. It is a zone marked by a large percentage of calms, the 5° square bounded by the tenth and fifteenth parallels and the eightieth and eighty-fifth meridians, in which the cyclone originated, having a percentage of 22. The bordering 5° squares show percentages as follows: North, 14; east, 12; south, 25; west, 37. The frequency of calms, as well probably as the existence of oppositely directed winds on either side, makes it a region favorable for the formation of cyclones. Indeed, one may well ask the question, Why do cyclones not form here in greater numbers?

While the meteorological features of the region, including the Isthmus of Panama and adjacent territory, have been very fully studied in recent years, it is desired to emphasize the annual changes that occur in the wind régime at the Isthmus as shown by the records of the Colon Observatory. An article by L. T. Chapel, of the Hydrographic Office, Cristobal, published in the MONTHLY WEATHER REVIEW for December, 1927, (1) deals very fully with wind conditions in the Panama area, and two diagrams which appeared in that article show the annual march of wind frequency and velocity at Colon and also at Cape Mala, 113 miles to the southward.

Inasmuch as something like three-fifths of the tropical cyclones that form in the western Caribbean occur in October and November, the behavior of the winds at this season of the year has a special significance. The diagrams referred to show clearly the decline in the frequency of northerly winds, which reach a minimum in October, and the concurrent decrease in velocity. Data are not adequate to show how far northward over the waters of the Caribbean this seasonal reversal of condition extends, but it appears likely that the area embraced includes that in which the majority, if not all, of the autumn hurricanes of this region have their origin.

In the general region of the western and southwestern Caribbean some 54 cyclones have had their origin in the past 44 years, or during the period 1887–1930, of which number 23 are known to have attained hurricane intensity. Out of the total some 22 have probably formed in approximately the same region as the one particularly under consideration, namely, that of 1926. Information, however, is not clear on this point in every instance. Of the extreme southwestern group, 10 occurred in October, 5 in November, 4 in September, 2 in June, and 1 in July.

Another preliminary meteorological fact is here well worth noting. Mitchell (2) has shown that tropical cyclones of the West Indies and North Atlantic Ocean develop principally in two general regions, one of which is the western Caribbean Sea; the other, the eastern part of the ocean near the Cape Verde Islands. In these localities, especially during specific periods, doldrum conditions in the North Atlantic are most fully developed. The existing records, extending now over many years, fail to show conclusively that any tropical cyclone has originated in the eastern part of the Caribbean Sea or adjacent areas of the Atlantic, and in this connection it may be explained that the tracks of tropical cyclones as depicted on the various charts start in many instances where the storm was first observed, perhaps fully developed, and that in some cases at least it is impossible to track the cyclone to its place of origin owing to lack of observations.

Ship and land observations in the southwestern Caribbean.—A distinguishing feature of this specific region, and one that merits the attention of students, is its favorable situation for the securing of observations. It is on this account one of the best suited of all bodies of water for the study of embryonic tropical cyclones at the present time, since many more observations are potentially available from this part of the Caribbean Sea than from almost any other originating locality. In recent years the greater part of the growth of shipping here, and therefore of potential weather observations, is, of course, due to the construction of the Panama Canal, which was opened to traffic in 1914. But a part also results from the development of the tropical-fruit industry and other South and Central American resources.

A circumstance that makes the early history of the 1926 cyclone of more than ordinary interest is the unusually full number of vessel observations available for the region and period of formation, as well as some highly interesting observations from near-by coastal stations. While even this number is not so numerous and well placed for study as could be wished, nevertheless it constitutes the best series on record covering the incipient stages of a tropical cyclone in these, if not in other, waters.

The land observations comprise those from the first-order stations at Colon and Balboa Heights, Panama Canal Zone, and Bluefields, Nicaragua. Compilations of wind and barometric data for the first two stations for the period October 13–20, 1926, kindly prepared by R. Z. Kirkpatrick, chief of surveys, the Panama Canal, appear herewith as Tables 1 and 2. Data for Bluefields for October 12 to 18, inclusive (7 a. m. and 7 p. m., seventy-fifth meridian time), are shown in Table 4. A record of pilot-balloon flights at the United States naval air station at Coco Solo, Canal Zone, near Colon, distant about 150 miles from the point of origin of the hurricane, appears in Table 3.

Formation and development of the storm.—The history of the hurricane in question of 1926 may be said to have

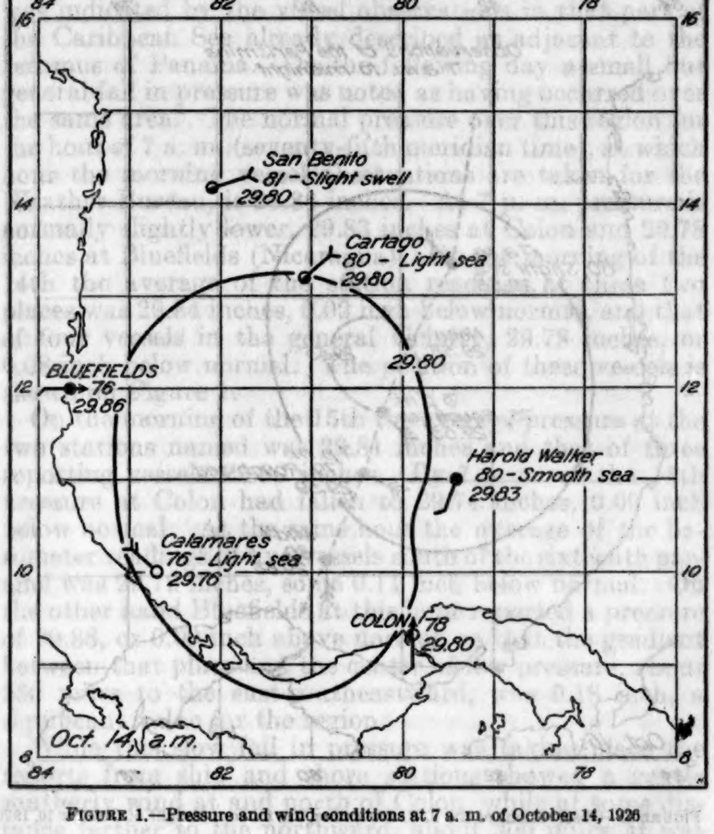


FIGURE 1.—Pressure and wind conditions at 7 a. m. of October 14, 1926

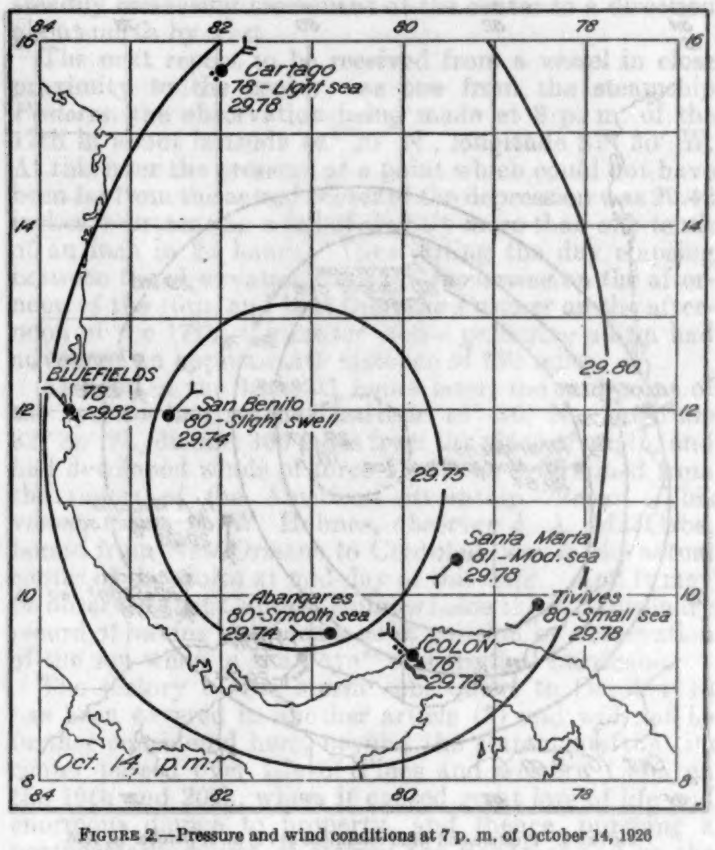


FIGURE 2.—Pressure and wind conditions at 7 p. m. of October 14, 1926

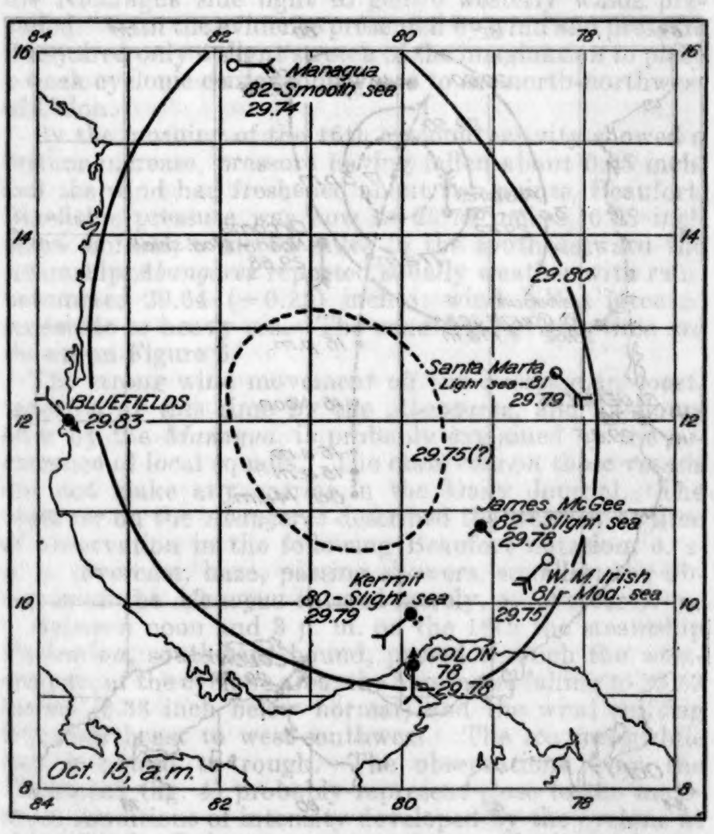


FIGURE 3.—Pressure and wind conditions at 7 a. m. of October 15, 1926

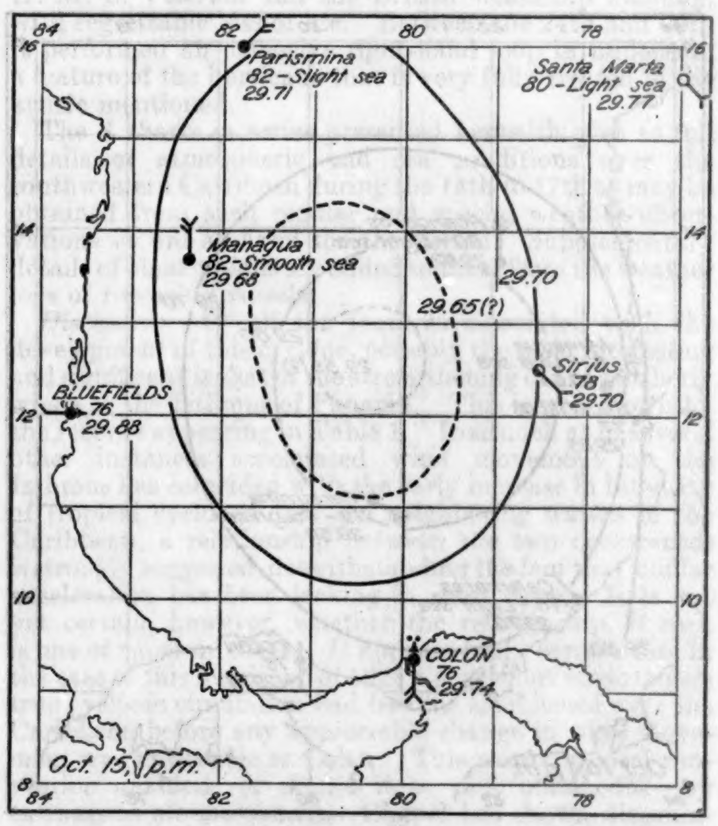


FIGURE 4.—Pressure and wind conditions at 7 p. m. of October 15, 1926

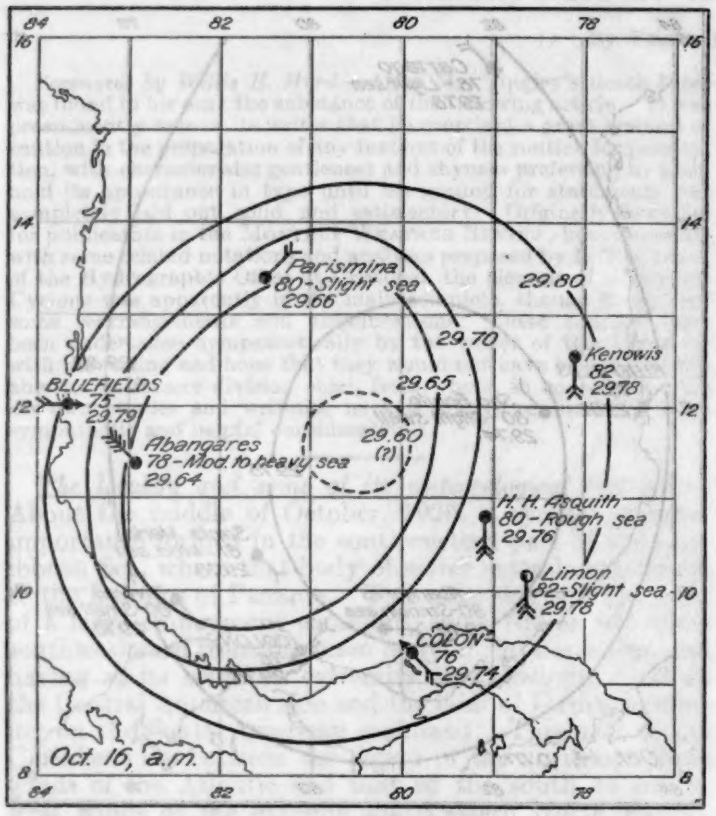


FIGURE 5.—Pressure and wind conditions at 7 a. m. of October 16, 1926

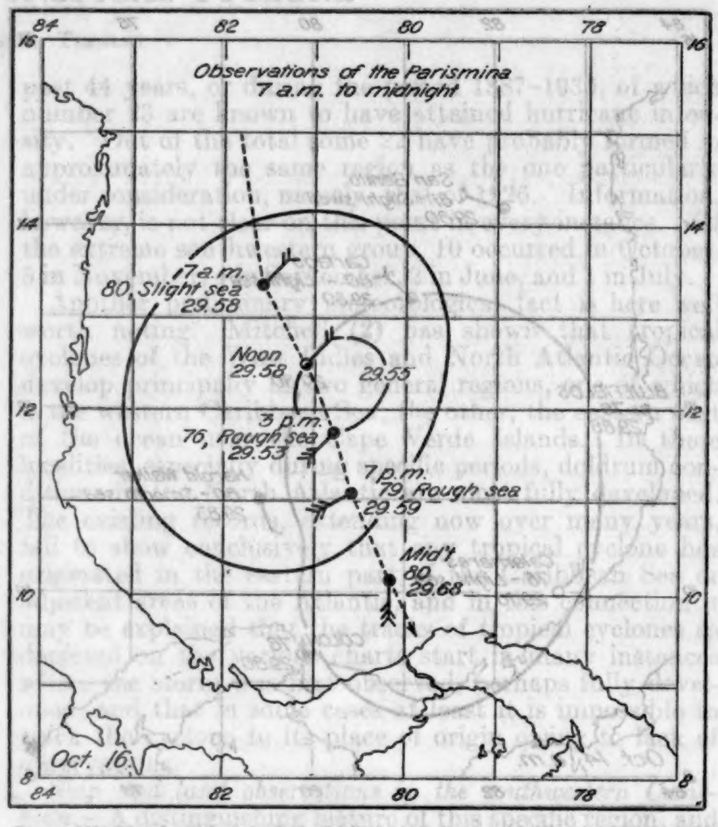


FIGURE 6.—Observations of the S. S. *Parismina*, 7 a. m. to midnight of October 16, 1926

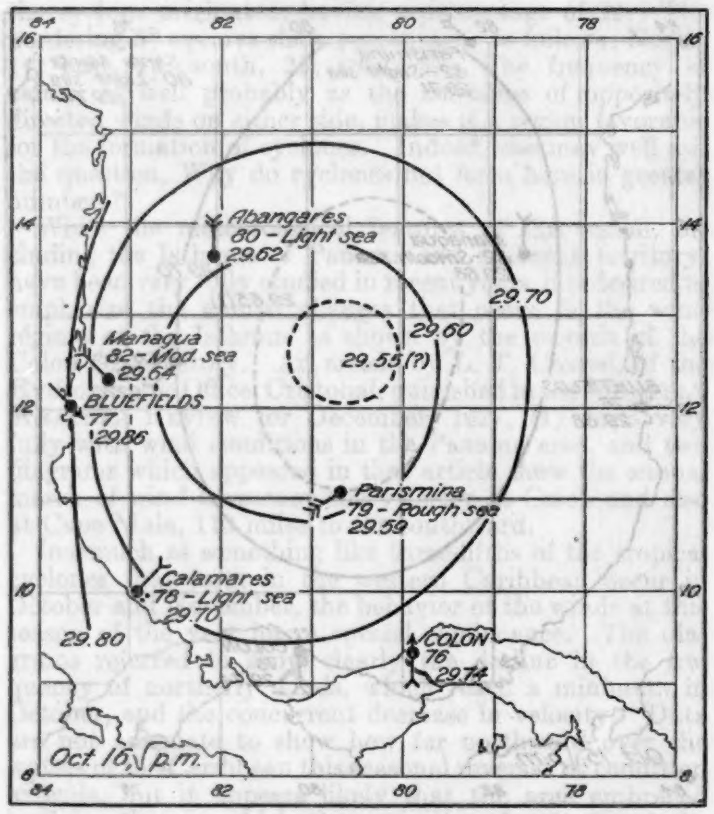


FIGURE 7.—Pressure and wind conditions at 7 p. m., of October 16, 1926

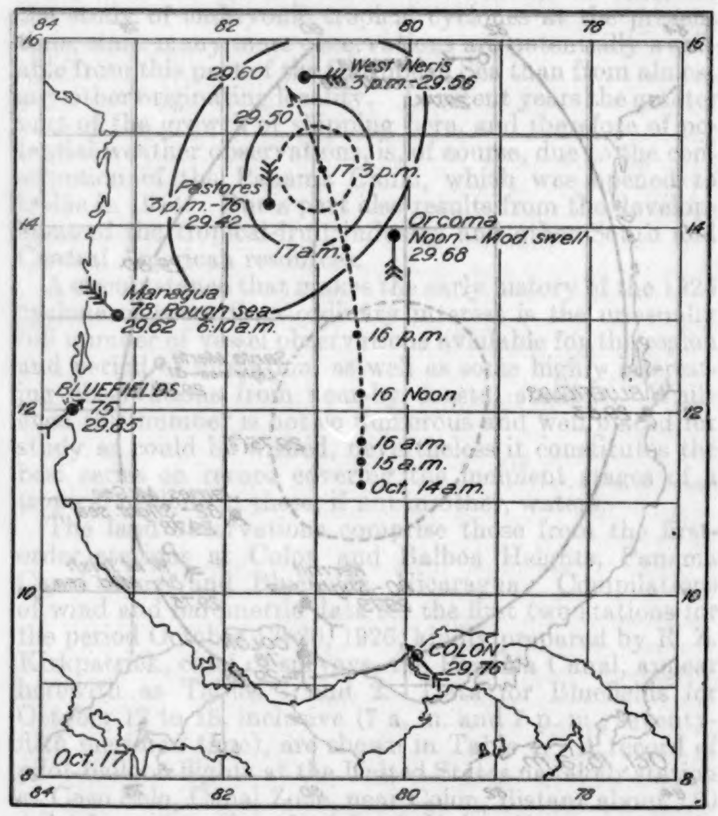


FIGURE 8.—Track of the tropical cyclone for the formative period, October 14–17, 1926. (The entire track will be found on Chart II, Monthly Weather Review, October. 1926)

begun on October 13, when a gentle cyclonic circulation was indicated by the vessel observations in that part of the Caribbean Sea already described as adjacent to the Isthmus of Panama. On the following day a small but general fall in pressure was noted as having occurred over the same area. The normal pressure over this region for the hour of 7 a. m. (seventy-fifth meridian time), at which hour the morning vessel observations are taken for the Weather Bureau, is 29.86 inches. At 7 p. m. pressure is normally slightly lower, 29.83 inches at Colon and 29.78 inches at Bluefields (Nicaragua). On the morning of the 14th the average of the station readings at these two places was 29.84 inches, 0.02 inch below normal, and that of four vessels in the general vicinity, 29.78 inches, or 0.08 inch below normal. The position of these vessels is shown on Figure 1.

On the morning of the 15th the average pressure at the two stations named was 29.81 inches and that of three reporting vessels 29.80 inches. By 7 p. m. of the 15th pressure at Colon had fallen to 29.74 inches, 0.09 inch below normal. At the same hour the average of the barometer readings of five vessels south of the sixteenth parallel was 29.72 inches, some 0.11 inch below normal. On the other hand Bluefields at this hour reported a pressure of 29.88, or 0.09 inch above normal, so that the gradient between that place and the center of low pressure, about 250 miles to the east-southeastward, was 0.18 inch, a significant value for the region.

While this slow fall in pressure was taking place the reports from ship and shore stations showed a gentle southerly wind at and north of Colon, while at some distance farther to the northward, about 300 miles, it was easterly and northeasterly, light to gentle as a rule. On the Nicaragua side light to gentle westerly winds prevailed. With the evidence presented by wind and pressure it required only a slight stretch of the imagination to place a weak cyclonic center somewhere to the north-northwest of Colon.

By the morning of the 16th cyclonic activity showed a further increase, pressure having fallen about 0.05 inch, and the wind had freshened about two points, Beaufort. Bluefields pressure was now at 29.79 inches, 0.08 inch below normal, while 75 miles to the southeastward the steamship *Abangarez* reported squally weather with rain; barometer 29.64 (−0.22) inches; wind NW., force 8; moderate to heavy sea. The conditions at this time are shown on Figure 5.

The strong wind movement off the Nicaraguan coast, reported at this time by the *Abangarez*, and 12 hours later by the *Managua*, is probably explained by the occurrence of local squalls. The observers on these vessels did not make any entries in the Daily Journal. The observer on the *Abangarez* described the weather at time of observation in the following Beaufort notation, *o. z p. q.* (overcast, haze, passing showers, squalls); the observer on the *Managua* entered merely, *o.* (overcast).

Between noon and 3 p. m. on the 16th the steamship *Parismina*, southward bound, passed through the western part of the cyclone area, the barometer falling to 29.53 inches (0.33 inch below normal) and the wind shifting from northeast to west-southwest. The sea meanwhile had increased to rough. The observations from the *Parismina* (fig. 4) probably represent close to the maximum conditions of intensity developed by the cyclone at that period. It is not apparent that much change in the location of the center had taken place between noon and 3 p. m. of the 16th, and the center at the latter hour may be placed close to latitude 12° 30′ N., longitude 80° 30′ W. From that time, however, there was a slow but steadily increasing movement of the center in a direction about north by west.

The next report to be received from a vessel in close proximity to the center was one from the steamship *Pastores*, the observation being made at 3 p. m. of the 17th in about latitude 14° 20′ N., longitude 81° 30′ W. At this hour the pressure at a point which could not have been far from the actual center of the depression was 29.42 inches, representing a fall of slightly more than one-tenth of an inch in 24 hours. Thus during the day elapsing between the observation from the *Parismina* on the afternoon of the 16th, and that from the *Pastores* on the afternoon of the 17th, the center of the gathering storm had advanced an approximate distance of 150 miles.

At noon of the 18th, 21 hours later, the mid-point of the cyclone had reached latitude 16° 30′ N., longitude 82° 30′ W., distant 300 miles from the place of origin, and had developed winds of force 11–12, as determined from the report of the American steamship *Atenas*. This vessel, Capt. E. W. Holmes, observer J. A. MacCabe, bound from New Orleans to Cristobal, was in the actual center of the storm at mid-day of this date. And it may be observed that Captain Holmes holds the extraordinary record of having obtained a noon position by observation of the sun when in the "eye" of a tropical hurricane.

The history of the storm subsequent to October 18 has been covered in another article (**3**) and will not be further considered here, beyond the statements that its center passed over Isle of Pines and western Cuba on the 19th and 20th, where it caused great loss of life and enormous damage to property, and thence, pursuing a northeasterly course, it crossed the Bahamas and on the 22d passed near Bermuda, where it caused the loss of H. M. S. *Valerian* and the British steamship *Eastway*, with regrettable loss of life. Between the 24th and 29th it performed an extensive right-hand loop in midocean, a feature of the hurricane that is very fully treated in the article mentioned.

The 8 charts in series presented herewith give as full details of atmospheric and sea conditions over the southwestern Carribean during the 14th to 17th as may be obtained from such regular and special weather observations as are at hand for the period. Supplementary details of observations are added to these from the weather logs of reporting vessels.

Discussion.—Of all the features associated with the development of this cyclone, possibly the most interesting and significant is that of the strengthening of the southerly winds at the Isthmus of Panama. This is well shown by the records appearing in Table 1. Inasmuch as in several other instances accelerated wind movement at the Isthmus has coincided with the early increase in intensity of tropical cyclones over the neighboring waters of the Caribbean, a relationship between the two occurrences is strongly suggested, notwithstanding the fact that similar acceleration has been lacking in some cases. It is not yet certain, however, whether the relationship, if real, is one of cause or effect. It appears fairly certain that in the case of this hurricane of 1926 a gentle but nevertheless true cyclonic circulation had become established over the Caribbean before any appreciable change in wind movement was noticeable at Colon. This points to local convection unaided—or should it be put, unimpeded—by extraneous air movement. Chapel has shown diagrammatically (1) that, on the average for the cyclones first reported south of latitude 15° N., the maximum frequency of southerly winds occurs on the second day of the storm's known existence as such. The fact that cyclones here form most frequently during October, when southerly

winds at Colon attain a maximum of frequency, would indicate that such winds are necessary in most if not all cases to cyclonic development.

At this point it will be illuminating to quote from Chapel on the relation between southerly winds and hurricane formations. He says:

In a comparison of southerly winds at Colon with the time of hurricane formation it is noted that for storms first reported north of latitude 15° the maximum of southerly winds at Colon usually precedes the first report by one or two days; but for storms originating south of latitude 15°, or within 300 miles of Colon, the maximum usually occurs on the day of reported formation or the day following. In other words, as far as the near-by storms are concerned, a cyclonic circulation actually exists and has been identified as such before the maximum of southerly wind occurs at Colon.

A comparison of all available records at Colon and Cape Mala indicates that the initial momentum of these southerly winds originates somewhere in the South Pacific, and that they extend northward with diminishing velocity, and are entirely independent of the existence of any cyclonic formation. According to fishermen and turtlers familiar with the southwestern Caribbean, the most obvious feature locally at the time of the formation of a tropical cyclone is frequently the southeast gales that persist, sometimes for several days, after the storm has passed. It would appear that the existence of a following wind in the wake of the moving storm, but distinct from the cyclonic circulation itself, is a reality, and that the influence of this wind in intensifying the already existing southerly winds over the Isthmus of Panama produces the comparatively high velocities which is their most noticeable feature.

The normal southerly winds at Colon are essentially light, 7 miles an hour on an average for a considerable term of years. The actual average hourly velocities at this place for October 13, 14, and 15, 1926, in advance of the onset of the stronger winds, were 5.8, 7.8, and 7.4 miles, respectively, or exactly 7 for the period. Inasmuch as fully developed cyclones form here on an average of only one every other year, it is apparent that the seasonal condition of light southerly winds must be very completely established and maintained for some time as an antecedent requisite.

In our specific case an advance of the northeast trades on a broad front at any time prior to October 15, such, for example, as occurred in October, 1930, would most probably have broken up the cyclone structure then in existence. On the other hand the fortuitous arrival of a narrow current of equatorial air that had found its way across the mountain barrier to the southward may have contributed the necessary impetus to the circulation.

The observed facts regarding the genesis of this hurricane may be summarized as follows: First, slightly reduced pressure and gentle cyclonic circulation over a region some 300 miles in diameter; second, a slow transition from this state to one of storm intensity, requiring at least three days to develop winds of gale force near the immediate center, although squalls formed locally within the affected area; third, a strengthening of the southerly winds at Balboa Heights, near the Pacific entrance to the Panama Canal, and distant nearly 250 miles from the point where the center was first definitely observed to be located, 24 hours before the center was observed; fourth, a slight increase in wind velocity above the 612-meter level, also before the observance of a center, at the naval air station at Coco Solo, near the Atlantic entrance to the Canal.

The increase in velocity at the Isthmus occurred first at Balboa Heights, at the greater distance from the cyclone center, and nearly the maximum velocity was reached rather abruptly on the 15th, high winds continuing until the 17th. On the Atlantic side, some miles nearer the cyclone center, there was a gradual acceleration to a well-marked maximum on the 18th. This difference in time suggests that the current of higher velocity was flowing at an angle to a line joining the two places, which would run about north-northeast from Balboa Heights. The explanation for the behavior of the wind probably lies in the topography of the Isthmus. It will be noted also that the maximum velocity at Colon was not reached until the cyclone center had traveled away from that place a distance of about 5°, or nearly 350 miles. Thus the wind velocity at Colon is shown as being, up to the 18th, in direct relation to the cyclone's energy, rather than to its distance away.

The record of pilot balloon flights at the Coco Solo Naval Air Station is regrettably marred by a gap embracing the critical dates of the 17th and 18th. This gap was occasioned by bad weather (rain) and the falling of the 17th on Sunday, on which day the morning observation was regularly suspended. It is therefore impossible to say definitely when the increase in wind movement at that place reached a maximum. It will be noted in Table 4 that the average of the velocities at the levels of 1,170, 1,350, and 1,530 meters was substantially the same as that for the lower levels of 216, 414, and 612 meters.

A point to be considered is that at the time of maximum velocity at Colon, that is, on the 18th, the direction of the wind was steadily southeast and apparently unrelated to the cyclonic circulation established to the northward. The reporting vessels, *El Lobo* and *Pastores*, 100 to 125 miles at sea, also were experiencing southeast winds, at variance with the circulation, and it is necessary on the day mentioned to go another 150 miles to the northward to find vessels within the field of the cyclonic circulation. Here are found the *Calamares*, *Limon*, *Managua*, and *San Benito* with southwest or south winds. The persistence of southeast winds after the passing of a cyclone was first brought to attention by Chapel in 1927.

Here the case must rest until additional evidence and further study can be combined to throw a clearer light on the formative processes of hurricanes in this region. A necessary step will be to examine areas of low pressure that form in the southwestern Caribbean and do not result in hurricanes; another to determine whether there are periods of accelerated wind movement at the Isthmus that do not coincide either with such low-pressure systems or fully developed storms. Data on this point are not available for incorporation in the present article.

In the initial stages of formation as here considered, the tropical cyclone is of more interest and moment to the meteorologist than to the mariner. During these stages weather and sea conditions are not yet sufficiently bad to cause concern to the latter and it therefore not surprising that observational details recorded by him are frequently meager. Therefore it may not be out of place here to emphasize the dependence of the student on the facts of observation—including details which must often have little or no apparent significance to the usual observer.

As an example of the type of weather development that may be expected in tropical seas during the early formative stages of a disturbance, the observations of a trained meteorologist during a period of unsettled weather in the Caribbean are of peculiar interest. The following quotation from some unpublished notes by L. T. Chapel will illustrate the point:

A development of this kind from a practically clear sky was observed by the writer on October 24, 1927, from the steamship *Cristobal* bound from Port au Prince to the Canal Zone. The position was 60 to 90 miles east to southeast of the island of Jamaica. At 10 a. m. the sky was almost clear with a few scattered

cumuli motionless near the horizon. Low strato-cumulus began to appear around the ship and shortly thereafter rain began to fall, an "April shower" condition. There were probably a dozen separate showers within view of the ship at once. The showers rapidly became squalls and the clouds piled up. By late afternoon the separate squalls had coalesced and a pall of alto-stratus overspread the west, northwest, and north, apparently a sharply defined cloud mass 25 to 30 miles in diameter and perhaps more, with heavy rain general. The wind was light easterly throughout except when a rain squall passed over the ship.

Following are additional details of observations of the hurricane of 1926 from the weather logs of reporting vessels:

WEATHER AND SEA CONDITIONS

October 14, 7 a. m.

Calamares.—Clear, no clouds; light NW. sea.
Cartago.—Cloudy, passing showers; 5 Cu., NE.; light NE. sea.
Harold Walker.—Overcast, squalls; 9 Cu. N., SE.; smooth (NW.) sea.
San Benito.—Cloudy; 6 Cu. and Ci. Cu., NE.; slight E. swell.

October 14, 7 p. m.

Abangarez.—Overcast, squalls; 9 A. S., W.; smooth sea.
Cartago.—Overcast, rain; 8 N., NE.; light NE. sea.
San Benito.—Overcast; 10 Cu. and Ci. S., E.; slight NE. swell.
Santa Marta.—Cloudy to overcast; 8 Cu. N., SW.; moderate SW. sea.
Tivives.—Cloudy; 7 Cu. N., SW., small W. sea.

October 15, 7 a. m.

Kermit.—Cloudy; 6 Cu., SSW., slight sea.
James McGee.—Cloudy, passing showers; 8 N., var.; slight sea.
Managua.—Cloudy; 3 Cu., E.; smooth (E.) sea.
Santa Marta.—Cloudy, passing showers; 7 Cu. N., SE.; light SE. sea.
W. M. Irish.—Clear to cloudy; 4 A. St., SW.; moderate SW. sea.

October 15, 7 p. m.

Managua.—Overcast; 9 Cu., NW.; smooth (E.) sea.
Parismina.—Overcast, passing showers, good visibility; 10 Ci. S., E.; slight E. sea.
Santa Marta.—Overcast; 9 Cu. N., SE.; light SE. sea.
Sirius.—Radio report only, details shown on chart.

October 16, 7 a. m.

Abangarez.—Overcast and hazy, passing showers and squalls; 10 A. S., NW.; moderate to heavy NW. sea.
H. H. Asquith.—Cloudy with drizzling rain at times; rough S'ly sea.
Limon.—Cloudy; 5 Cu., SW.; slight sea.
Kenowis.—Radio report only, details shown on chart.
Parismina.—Cloudy, passing showers, good visibility; N. and Cu. N., ESE.; slight sea.

October 16

Parismina.—Noon, partly cloudy; light swell. 3 p. m., cloudy; rough sea.

October 16, 7 p. m.

Abangarez.—Overcast, passing showers and squalls, good visibility; 9 Cu. N., NNE.; light NE. sea.
Calamares.—Overcast, rain; 10 Cu. and N., E.; light E. sea.
Managua.—Overcast; 10 Cu., NE.; moderate E. sea.
Parismina.—Overcast with haze, rain, squally; rough sea.

October 17

Managua.—7 a. m., overcast; 10 Cu., NW.; rough E. sea.
Pastores.—3 p. m. Radio report only, details shown on chart.
West Neris.—7 a. m. Overcast, gloomy, rain; 10 Cu. N. and N., S'ly; small S'ly sea; 10 a. m., wind backed from S. to E., fresh; 4 p. m., backed to NE., strong. Experienced low barometer (29.56 inches) in latitude 15° 39′ N., longitude 81° 10′ W. (About 3 p. m., estimated.)

Special mention may be made of the singular experience of the royal mail steamer *Orcoma*, which, after overtaking and passing the gathering cyclone on October 17, while en route from Panama to Habana, was herself overtaken by the cyclone, then a fully developed hurricane, while lying in Habana Harbor on the 20th. The report of the *Orcoma* is taken from the Marine Observer, published by the British Meteorological Office, issue of September, 1927. The speed of the *Orcoma* was approximately 14 miles (statute) per hour. The weather experienced during the 17th was as follows:

4 a. m. Wind S., force 4; barometer 29.75 inches; temperature, air, 78°; overcast, frequent torrential showers; squally, with some thunder and lightning; moderate SSW. swell.

Noon. Position, latitude 13° 53′ N., longitude 80° 09′ W. (D. R.); wind S., 5; barometer 29.68; temperature 78°; overcast with rain; moderate SSW. swell.

3 p. m. Violent squall, force 10 (S.); temperature fell 4.5° before squall, rising again with passage.

4 p. m. Wind S., 6; barometer 29.53 inches; overcast with rain squalls; moderate SW. swell.

8 p. m. Wind S., 5; barometer 29.65 inches; temperature 80°; overcast with rain squalls; heavy SSW. swell.

Midnight. Wind SSW., 4; barometer 29.62 inches; temperature 79°; overcast with rain squalls; heavy SSW. swell.

NOTE.—All of *Orcoma's* barometer readings are corrected for height, gravity, and diurnal variation.

TABLE 1.—*Colon, October, 1926, hourly wind direction and velocity; hourly pressure*

Date	A. M.												P. M.												Mean
	1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11	Mid't	
HOURLY WIND DIRECTION																									
13	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	sw.	w.	w.	w.	w.	w.	sw.	sw.	s.	s.	s.	s.	s.	------
14	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	sw.	sw.	sw.	sw.	w.	sw.	sw.	se.	s.	s.	s.	s.	s.	s.	------
15	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	sw.	s.	s.	s.	s.	s.	s.	se.	se.	se.	------
16	s.	s.	s.	se.	se.	se.	se.	se.	se.	s.	s.	s.	s.	s.	w.	sw.	s.	s.	s.	s.	se.	se.	se.	se.	------
17	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	s.	s.	s.	s.	s.	s.	s.	s.	s.	se.	se.	se.	------
18	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	------
19	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	se.	------
20	se.	se.	se.	se.	se.	se.	se.	se.	se.	s.	s.	sw.	w.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	------
HOURLY WIND VELOCITY, M. P. H.																									
13	3	2	4	4	4	5	5	5	7	6	7	11	13	10	5	4	5	5	7	5	4	6	6	6	5.8
14	8	6	5	5	6	5	5	7	8	11	13	10	9	10	13	7	8	9	8	7	8	7	5	6	7.8
15	5	5	6	6	5	6	5	5	7	6	7	10	11	11	4	2	3	8	8	9	12	12	13	12	7.4
16	12	12	11	12	11	9	8	11	12	11	12	11	15	16	16	12	8	8	5	7	7	8	8	7	10.4
17	7	12	13	14	16	13	15	12	16	17	18	18	15	12	11	10	8	7	6	6	5	6	5	8	11.2
18	9	11	14	14	18	16	19	19	19	20	21	21	21	20	19	18	15	13	12	12	11	11	7	9	15.4
19	9	5	9	8	7	9	9	10	10	13	13	13	12	12	11	11	11	8	8	5	6	6	5	4	8.9
20	5	4	5	4	4	6	5	6	5	6	8	8	11	13	11	10	8	7	6	3	4	1	3	3	6.1
HOURLY PRESSURE, 29 INCHES PLUS																									
13	0.81	0.80	0.79	0.79	0.79	0.81	0.82	0.84	0.86	0.86	0.85	0.82	0.80	0.77	0.75	0.75	0.77	0.79	0.79	0.80	0.81	0.83	0.82	0.80	------
14	.79	.78	.76	.76	.77	.79	.80	.81	.83	.83	.82	.81	.78	.75	.73	.73	.74	.75	.76	.77	.77	.77	.76	.76	------
15	.74	.73	.73	.73	.74	.76	.77	.79	.81	.79	.76	.73	.71	.71	.71	.70	.71	.73	.73	.74	.75	.75	.74	.73	------
16	.71	.70	.68	.69	.70	.71	.73	.74	.76	.76	.75	.72	.70	.68	.67	.67	.69	.70	.71	.74	.75	.75	.74	.73	------
17	.71	.69	.68	.68	.70	.71	.74	.77	.78	.79	.78	.76	.74	.71	.70	.71	.73	.74	.76	.78	.79	.79	.79	.78	------
18	.77	.76	.76	.75	.75	.79	.81	.83	.85	.83	.81	.80	.77	.74	.72	.72	.74	.76	.78	.80	.81	.81	.82	.81	------
19	.80	.79	.78	.77	.78	.79	.80	.82	.83	.84	.83	.80	.78	.75	.74	.72	.72	.72	.75	.77	.80	.82	.83	.82	------
20	.81	.79	.78	.76	.77	.79	.81	.82	.84	.85	.83	.81	.78	.75	.72	.70	.72	.76	.70	.78	.80	.82	.82	.81	------

TABLE 2.—*Balboa Heights, Canal Zone, October, 1926, hourly wind direction and velocity; hourly pressure*

Date	A. M. 1	2	3	4	5	6	7	8	9	10	11	Noon	P. M. 1	2	3	4	5	6	7	8	9	10	11	Mid't	Mean
HOURLY WIND DIRECTION																									
13	nw.	nw.	nw.	nw.	ne.	ne.	ne.	ne.	ne.	ne.	e.	se.	s.	s.	nw.	nw.	se.	nw.	nw.	nw.	n.	ne.	ne.	ne.	------
14	ne.	ne.	ne.	ne.	ne.	n.	n.	n.	n.	n.	ne.	ne.	se.	se.	s.	sw.	se.	s.	s.	sw.	s.	sw.	s.	s.	------
15	s.	s.	sw.	w.	sw.	sw.	sw.	sw.	s.	sw.	sw.	s.	s.	s.	s.	sw.	s.	s.	s.	s.	s.	s.	s.	s.	------
16	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	sw.	s.	sw.	s.	s.	s.	s.	s.	------
17	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	------
18	s.	s.	s.	s.	s.	se.	s.	s.	s.	se.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	------
19	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	se.	se.	s.	se.	se.	se.	se.	se.	ne.	ne.	------
20	ne.	ne.	ne.	ne.	ne.	ne.	ne.	ne.	ne.	ne.	ne.	se.	se.	se.	se.	se.	se.	se.	se.	se.	ne.	ne.	nw.	nw.	------
HOURLY WIND VELOCITY, M. P. H.																									
13	2	2	3	4	2	6	4	6	7	5	5	5	7	9	3	3	2	3	2	2	4	7	6	3	4.3
14	6	6	7	4	3	2	3	2	1	3	5	5	5	8	8	2	4	7	6	14	9	8	17	20	6.5
15	12	12	6	2	5	3	1	1	14	22	24	21	25	26	25	23	19	18	17	14	16	15	23	23	15.3
16	22	21	21	22	18	18	22	23	27	28	23	20	21	24	21	19	22	17	16	18	14	19	19	22	20.7
17	21	19	19	28	28	24	26	23	27	29	24	23	24	24	22	26	17	11	11	6	9	14	14	17	20.2
18	14	10	12	12	11	9	13	16	18	18	18	18	19	17	17	14	13	15	10	9	10	10	11	11	13.5
19	14	16	10	10	14	12	11	11	18	17	17	14	18	14	11	7	8	7	6	6	4	5	5	10	11.0
20	9	6	9	10	9	6	4	6	5	6	5	8	7	6	5	6	4	5	5	2	6	9	2	1	5.9
HOURLY PRESSURE, 29 INCHES PLUS																									
13	0.82	0.80	0.79	0.80	0.79	0.81	0.84	0.86	0.87	0.87	0.84	0.82	0.80	0.78	0.76	0.76	0.76	0.78	0.80	0.80	0.81	0.83	0.82	.81	------
14	.79	.78	.77	.77	.78	.80	.81	.82	.84	.85	.83	.82	.78	.76	.75	.75	.76	.75	.76	.78	.79	.78	.77	.76	------
15	.75	.73	.73	.73	.73	.75	.78	.80	.82	.81	.80	.78	.75	.74	.73	.74	.75	.76	.77	.78	.80	.80	.79	.77	------
16	.75	.74	.73	.74	.75	.76	.77	.77	.80	.80	.78	.77	.74	.72	.71	.70	.72	.73	.74	.75	.77	.78	.77	.75	------
17	.73	.71	.70	.70	.73	.75	.78	.78	.80	.82	.81	.80	.77	.75	.73	.72	.75	.75	.77	.80	.81	.81	.81	.81	------
18	.80	.78	.77	.76	.76	.80	.82	.84	.86	.86	.84	.81	.79	.77	.75	.75	.77	.78	.79	.81	.82	.83	.84	.83	------
19	.82	.81	.81	.80	.80	.81	.83	.84	.86	.85	.83	.81	.79	.76	.75	.74	.74	.74	.76	.78	.81	.81	.81	.81	------
20	.79	.78	.75	.75	.77	.80	.81	.83	.85	.85	.82	.80	.77	.74	.72	.70	.71	.73	.76	.78	.82	.83	.83	.82	------

TABLE 3.—*Wind direction and velocity at different levels, as shown by pilot balloon ascensions at the United States Naval Air Station, Coco Solo, Canal Zone, during formation of a tropical cyclone in the southwestern Caribbean Sea, October, 1926.*

Flight No. (1926)	349.	350.	351.	353.	354.	355.	356.	357.	358.	359.	360.
Date and hour	13th, 0630.	13th, 1500.	14th, 0630.	14th, 1500.	15th, 0630.	16th, 0630.	18th, 0630.	18th, 1500.	19th, 0630.	19th, 1500.	20th, 0630.
Surface wind, direction and velocity.	SE., 0.9.	WSW., 3.1.	SE., 2.2.	W., 3.6.	S., 1.8.	SE., 3.6.	SE., 8.9.	SE., 8.9.	ESE., 5.4	E., 5.4.	SE., 1.3.
Air temperature and humidity.	74°, 95 per cent.	84°, 84 per cent.	76°, 96 per cent.	81°, 87 per cent.	75°, 95 per cent.	75°, 95 per cent.	76°, 87 per cent.	85°, 73 per cent.	75°, 91 per cent.	88°, 67 per cent.	74°, 95 per cent.
Pressure	29.79.	29.76.	29.77.	29.72.	29.75.	29.70.	29.77.	29.72	29.79.	29.73.	29.82.
Upper clouds	1 CiS.	2 CiS.	6 CiS N.	3 CiS N.	2 CiS.	2 CiS NE.	5 CiS NE.	4 CiS NE.	8 CiS NW.	8 CiS NW.	5 CiS NW
Intermediate clouds	2 ACu.					2 ACu NE		2 ACu NE.			
Lower clouds	6 SCu W.	4-2 Cu-SCu SE.	3 SCu NW.	3/4 Cu/SCu SW.	7 SCu SW	4 SCu SW	5 SCu S	2 Cu S	1 SCu.	1 Cu SE.	2 Cu NE.
Visibility	6.	6.	6.	7.	6.	6.	6	6.	6.	6.	6.
Sun	Obscured.	Bright.	Intermittent.	Obscured.	Faint.	Obscured.	Intermittent.	Bright.	Intermittent.	Bright.	Bright.
Disappearance due to	Haze.	Bursting.	Haze.	SCu clouds.	SCu clouds.	Haze.	SCu clouds.	Fading, CiS.	Fading, CiS.	Haze.	Bursting.

Altitude of balloon: Minute	Meters	Wind: Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
1	216	sse.	5.0	wsw.	2.1	sse.	5.0	ssw.	4.8	s.	4.6	sse.	8.3	se.	13.0	se.	7.5	ese.	9.7	ese.	8.0	ese.	4.7
2	414	ssw.	5.0	ssw.	2.5	s.	5.2	ssw.	4.0	ssw.	5.0	s.	10.6	sse.	15.8	se.	7.8	se.	11.6	ese.	8.3	ese.	3.6
3	612	sw.	4.5	sw.	3.8	wsw.	4.7	ssw.	4.2	sw.	5.8	s.	14.0	sse.	15.2	se.	8.9	se.	11.7	ese.	7.4	se.	2.8
4	801	wsw.	4.5	sw.	3.8	wsw.	3.1	ssw.	3.8	sw.	5.9	s.	13.3	sse.	14.3	sse.	10.5	se.	10.8	ese.	6.0	ese.	3.4
5	990	wsw.	4.5			wsw.	2.0			wsw.	5.8	s.	10.4	sse.	15.0	sse.	11.3	se.	10.3	se.	4.7	e.	3.8
6	1,170	w.	3.8			w.	1.6			wsw.	6.2	ssw.	10.2	sse.	16.6	sse.	10.8	se.	10.2	s.	3.0	ne.	3.4
7	1,350	w.	3.0			w.	1.4			wsw.	6.9	ssw.	11.0	s.	17.5	sse.	8.6	se.	9.5	s.	2.0	ne.	3.4
8	1,530	w.	2.9			nw.	1.2			sw.	7.6	ssw.	12.7			s.	6.4	se.	8.5	se.	1.0	ne.	3.7
9	1,710	w.	2.7			nnw.	1.3					sw.	14.3			s.	6.6	se.	8.3			ne.	3.0
10	1,890	wsw.	2.9			nw.	1.5															ne.	2.4
11	2,070	wsw.	2.5			nw.	2.0															nne.	3.7
12	2,250	ssw.	2.9			nnw.	2.9															nne.	5.7
13	2,430	s.	2.7			n.	3.4															nne.	6.3
14	2,610	sse.	2.5			n.	3.2															nne.	5.8
15	2,790	sse.	2.6			n.	3.0															nne.	6.0

Flight 352. made at 0745 on the 14th omitted.

TABLE 4.—*Weather conditions at Bluefields, Nicaragua, at a. m. and p. m. observations, October 12–18, 1926 (From Form 1001 A)*

Day and hour	Barometer	Temperature	Wind direction	Velocity	Weather	Rainfall
	Inches	°		*M. p. h.*		*Inches*
12th, a.	29.88	75	w.	4	Cloudy	.57
12th, p.	29.88	80	0.	0	Partly cloudy	.00
13th, a.	29.88	76	nw.	2	Cloudy	.53
13th, p.	29.88	81	nw.	2	Partly cloudy	.05
14th, a.	29.86	76	w.	4	Cloudy	.12
14th, p.	29.83	78	nw.	2	do	.10
15th, a.	29.79	76	nw.	6	do	.61
15th, p.	29.88	76	w.	2	do	.15
16th, a.	29.70	75	w.	10	Rain	1.47
16th, p.	29.86	77	nw.	2	do	1.00
17th, a.	29.88	75	sw.	6	Cloudy	.00
17th, p.	29.77	82	sw.	4	do	.00
18th, a.	29.86	75	sw.		do	.00
18th, p.	29.84	80	sw.	4	Rain	.07

LITERATURE CITED

(1) Chapel, L. T. Winds and storms on the Isthmus of Panama. M. W. R., vol. 55, December, 1927. Pp. 519–530.

(2) Mitchell, Charles L. West Indian hurricanes and other tropical cyclones of the North Atlantic Ocean. M. W. R., Sup. No. 24, 1924.

(3) Hurd, Willis Edwin. The North Atlantic hurricane of October 13–29, 1926. H. O. Pilot Chart, North Atlantic Ocean, October, 1930.

"SAN NICOLÁS"—THE TROPICAL STORM OF SEPTEMBER 10, 1931, IN PORTO RICO

By F. E. HARTWELL

[Weather Bureau, San Juan, P. R.]

According to the accustomed nomenclature of West Indian storms the one which raked the north coast of Porto Rico on the night of September 10 has been named "San Nicolás" from the saint's day of that date. The first intimation of abnormal weather previous to this storm was an almost perfect wide quadrant of wind directions extending from the Virgin Islands to Barbados on the morning of the 9th. The appearance at that time was that the area named was in the southwest periphery of a very wide cyclonic area. Broadcasts were immediately sent out in an endeavor to locate the center and

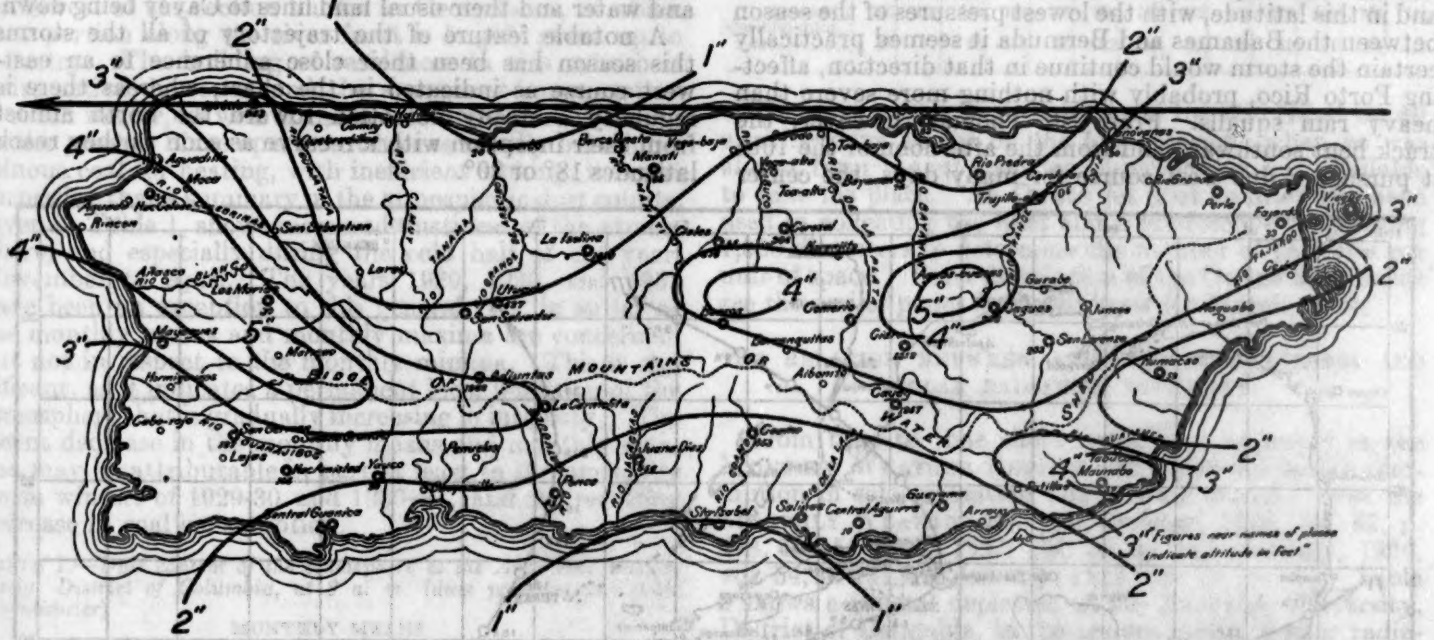


FIGURE 1.—Distribution of rainfall in Porto Rico during hurricane of "San Nicolás," September 10-11, 1931. (Arrow shows path of center)

determine its intensity, but nothing of importance was received and by evening the low area had become elongated in a north-south direction, the southern extremity apparently filling up and the northern developing into a vortex of much narrower limits than at first indicated. Nothing below 29.72 inches (at St. Martin and Antigua) was reported, and no velocities above ordinary occurred within range of reporting stations. By the morning of the 10th the center had passed through the Leewards somewhere near St. Martin and was approaching the U. S. Virgin Islands of St. Thomas and St. Croix. The bulletin issued from the San Juan office that morning was as follows:

> Advisory 9.00 a. m.—Sept. 10, 1931.—Disturbance of minor intensity has apparently passed through Leeward Islands and is approaching St. Thomas and St. Croix and will probably affect northeastern Porto Rico before midnight. No high winds have so far been reported and the lowest pressure is 29.72 inches at St. Martin. Caution advised small shipping on east coast of Porto Rico particularly.
>
> (Signed) HARTWELL.

Our special observers at St. Croix and St. Thomas sent the required messages and indications pointed to the path slightly north of the latter station, where by mid-afternoon the storm had developed to 60 miles per hour with northwest shifting to west winds and a low pressure of 29.57 inches. By the time it had reached San Juan the intensity had increased to a low pressure of 29.17 inches and an estimated wind velocity of 90 miles per hour. This estimate is based partially upon a stop watch record made by Pan-American Airways (Inc.) officials with their 4-cup Robinson anemometer at the air field and, of course, the total mileage and the dial readings of our own anemometer.

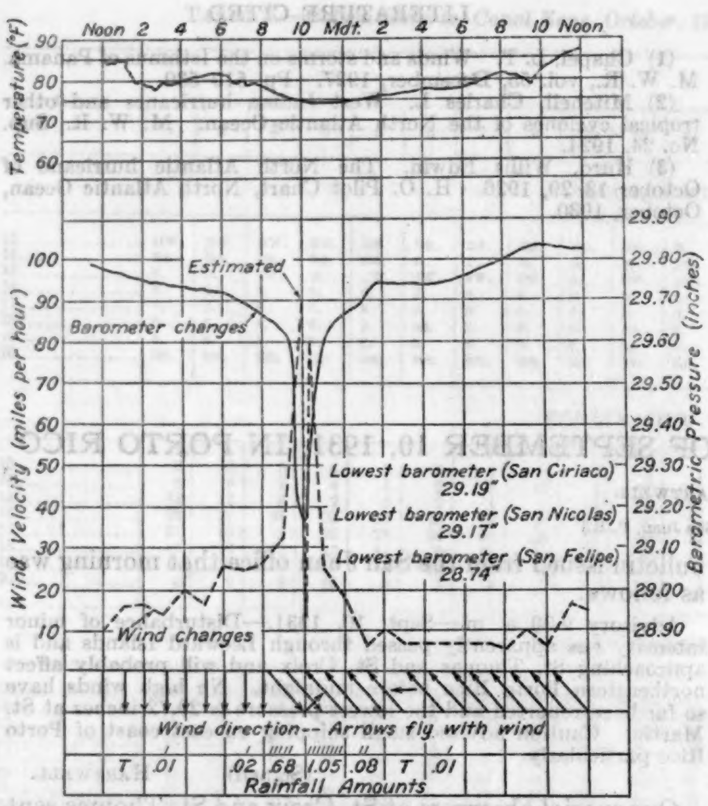


FIGURE 2.—Weather elements at San Juan, P. R., hurricane of September 10-11, 1931

So far the trajectory had been close to west-northwest and in this latitude, with the lowest pressures of the season between the Bahamas and Bermuda it seemed practically certain the storm would continue in that direction, affecting Porto Rico, probably with nothing more severe than heavy rain squalls. From St. Thomas, however, the track bent southward and from the afternoon of the 10th it pursued a due west course for many days, the center passing along the north coast of Porto Rico, with decreased intensity over Santo Domingo City, then again increasing throughout the remaining length of the Caribbean Sea. This trajectory is shown in the accompanying chart of storm tracks for this area this season.

In Porto Rico, while the information of Thursday evening was perhaps too sanguine, indicating that the center would probably pass as much a 50 miles north of San Juan, the warning of the morning had been well heeded and some preparation was effected where practicable. Two lives were lost and several minor injuries reported in San Juan. Much plate glass and light construction were destroyed, and some 50,000 boxes of fruit blown from the trees. The damage was confined to a strip of 5 or 6 miles in width extending from San Juan to Aguadilla, the damage varying considerably in this area with the character of the crops. The destructive portion of the storm was hardly more than 10 or 12 miles in diameter and the northern half of this was off shore. There was an interval of 15 minutes at San Juan which represented the center of the storm, but it is the opinion of the writer that the actual center passed a short distance north of San Juan as the first renewal of the wind was from the southwest, then after several minutes it became southeasterly. The wind during the first portion of the storm held northwest with practically no variation until the lull.

All electric service was broken and definite news of the passage of the center was sent out through the cooperation of the officials of the Spanish liner *Juan Sebastian Elcano* who communicated the dispatches to the main broadcasting station of the naval radio at Cayey, the local station of that service being badly crippeld by both wind and water and their usual land lines to Cayey being down.

A notable feature of the trajectory of all the storms this season has been their close adherence to an east-west course as indicated in the chart, whereas there is regularly a steady deviation toward the north almost from their inception with a recurve as soon as they reach latitudes 18° or 20°.

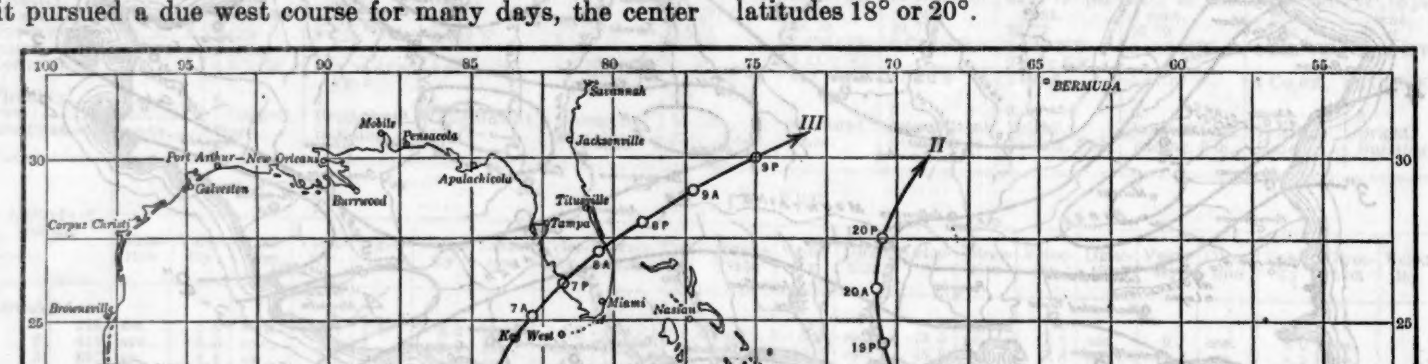


FIGURE 3.—Paths of hurricanes of 1931 (Plotted by Arthur J. Haidle): I, August 10-18 II, August 16-20; III, September 1-9; IV, September 5-12; V, September 8-15 ("San Nicolás")

INVESTIGATIONS OF THE DUST CONTENT OF THE ATMOSPHERE

By HERBERT H. KIMBALL and IRVING F. HAND

[Solar Radiation Investigations Section, U. S. Weather Bureau]

SYNOPSIS

This paper is a continuation of papers on the same subject that appeared in the MONTHLY WEATHER REVIEW for March, 1924, and June, 1925. It summarizes measurements of the dust content of the atmosphere made on the campus of the American University, District of Columbia, between December, 1922, and June, 1931, inclusive, excluding the month of June, 1923. This gives 9-year means for the winter and spring months and 8-year means for the summer and fall. The monthly averages and the annual totals show a gradual increase in the dust content of the atmosphere for the years 1923–1928, with a slight decrease in the years 1929 and 1930. Records of the total solar radiation received on a horizontal surface show that an increase in atmospheric dust has been accompanied by a decrease in the solar radiation intensity during the cold half of the year, November to April, inclusive, without a corresponding decrease during the warm months of the year. The greatest percentage of increase in the atmospheric dust content is shown in the minimum amount recorded in each month, where the annual average for 1930 was more than double that for 1923 and 1924.

This increase in local atmospheric dust does not appear to have been accompanied by a corresponding decrease in the distance to which prominent objects like mountain peaks and high hills can be seen.

A relation is shown between the sulphur (SO_2) content and the dust content of the atmosphere.

SUMMARY OF ATMOSPHERIC DUST MEASUREMENTS

The campus of the American University, District of Columbia, where atmospheric dust measurements have been made by the United States Weather Bureau since December, 1922, is in a sparsely settled suburb of Washington about 5½ miles northwest of the United States Capitol, 5 miles from all important railroads, and 2 miles northwest of the section known as Georgetown, of which that portion along the river front is largely given up to industry. The building of residences in this suburb is quite active, however, and the apartment-house section is much nearer, as well as more extensive, than it was in earlier years. Since apartment houses usually burn bituminous coal for heating, with inefficient stoking, it is not surprising that a summary of the atmospheric dust counts, given in Table 1, shows increased dustiness of the atmosphere, and especially during the cold half of the year, November to April. The years 1929, 1930, and 1931 have been an exception to this general rule, in so far as the monthly means and monthly maxima are concerned, but not in respect to the monthly minima. This is significant, as it indicates a permanent local pollution of the atmosphere that is gradually increasing in intensity. The recent decrease in the monthly means and monthly maxima may be attributable in part at least to the unusually warm winters of 1929-30 and 1930–31, and the resulting decrease in coal consumption.

TABLE 1.—*Dust content of the atmosphere at the American University, District of Columbia, at 8 a. m. (dust particles per cubic centimeter)*

MONTHLY MEANS

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual means
1922	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1,228	-----
1923	1,061	905	540	476	393	-----	397	388	386	395	451	557	540
1924	719	533	409	645	376	420	539	326	335	598	1,110	1,159	597
1925	723	1,092	909	753	416	507	480	484	514	608	787	1,444	726
1926	1,631	1,517	1,370	755	573	578	542	532	565	692	851	1,056	888
1927	1,011	1,116	939	721	729	607	933	760	859	1,021	1,097	1,176	914
1928	1,455	1,450	1,232	856	668	596	757	675	774	1,082	979	1,227	978
1929	1,419	1,086	652	610	621	469	549	626	638	616	858	881	752
1930	898	736	668	753	614	544	573	828	866	1,020	995	875	781
1931	906	951	809	815	608	631	-----	-----	-----	-----	-----	-----	-----
Average	1,091	1,043	836	709	555	544	596	577	617	754	891	1,047	772

TABLE 1.—*Dust content of the atmosphere at the American University, District of Columbia, at 8 a. m. (dust particles per cubic centimeter)*—Continued

MAXIMUM

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual means
1922	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2,088	-----
1923	3,680	2,050	1,155	1,182	905	-----	793	794	812	853	1,023	2,340	1,394
1924	2,403	1,964	1,280	1,661	1,154	1,250	1,953	796	823	1,366	1,987	2,551	1,595
1925	1,352	2,370	2,247	7,077	781	991	1,016	1,037	1,109	1,432	1,558	3,106	2,006
1926	3,828	2,995	2,999	1,527	1,042	1,035	985	941	1,073	1,426	3,975	2,388	2,018
1927	3,511	2,474	1,877	1,558	1,529	1,560	1,651	1,443	1,672	3,133	2,566	2,984	2,163
1928	3,620	3,557	2,617	2,039	1,575	1,434	1,308	1,302	1,493	2,772	2,751	4,116	2,382
1929	3,620	1,982	1,583	1,153	1,082	897	922	976	1,010	1,098	1,628	1,606	1,463
1930	3,780	1,512	1,176	1,166	1,701	855	1,052	1,323	1,426	2,066	1,953	1,779	1,649
1931	1,617	1,649	1,352	1,434	846	1,073	-----	-----	-----	-----	-----	-----	-----
Average	3,046	2,284	1,810	2,089	1,179	1,137	1,210	1,076	1,177	1,761	2,180	2,551	1,792
Absolute maximum	3,828	3,557	2,999	7,077	1,701	1,560	1,953	1,443	1,672	3,133	3,975	4,116	-----

MINIMUM

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual means
1922	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	298	-----
1923	214	105	113	113	65	-----	90	110	59	96	71	90	108
1924	124	97	76	151	124	155	124	87	97	155	113	124	118
1925	57	77	87	202	149	197	132	143	118	130	124	344	147
1926	160	298	223	227	187	214	218	145	132	82	76	145	176
1927	155	185	145	138	225	122	288	187	218	99	172	143	173
1928	160	254	162	174	126	202	384	132	126	334	120	109	190
1929	160	200	101	242	134	128	170	191	176	124	323	204	170
1930	361	253	237	241	134	178	150	144	278	384	231	376	247
1931	372	369	174	233	275	216	-----	-----	-----	-----	-----	-----	-----
Average	196	204	146	191	158	176	194	142	150	176	154	204	174
Absolute minimum	57	77	76	113	65	122	90	87	59	82	71	90	-----

The dust counts have been made by Mr. Hand on all working days except on the few occasions when he was absent from the city and an observer was not available to take his place. An Owens jet dust counter has been used in collecting the dust and a microscope magnifying 1,000 diameters to determine the number of particles per unit of space. For a description of the Owens instrument see the earlier paper in the REVIEW for March, 1924.

THE RELATION BETWEEN ATMOSPHERIC DUSTINESS AND SOLAR RADIATION INTENSITY

From time to time short notes have appeared in the MONTHLY WEATHER REVIEW with reference to the diminution in solar radiation due to local smoke. (See the MONTHLY WEATHER REVIEW, October, 1924, vol. 52, p. 478, fig. 5; April, 1925, vol. 53, p. 147; January, 1926, vol. 54, p. 19; and January, 1929, vol. 57, p. 18.) Table 2 shows a general depletion at the American University, District of Columbia, in the annual totals of solar radiation for 1923–1928, and in the monthly averages during the cold part of the year for the period 1923–1930. The monthly averages for the warm part of the year show little departure from normal values. The depletion in solar radiation intensity is what would be expected from the increase in atmospheric dustiness shown in Table 1.

A similar decrease in solar radiation intensity recorded at Madison, Wis., is attributed by the official in charge of that station to increased smokiness of the atmosphere due to a marked increase in the population of the section of the city in which the Weather Bureau office is located. (See the MONTHLY WEATHER REVIEW, 1931, vol. 59, p. 272.)

TABLE 2.—*Departures of monthly totals of solar radiation received on a horizontal surface at Washington, D. C., from monthly normal values for the period 1914–1931 (gram-calories per cm.²)*

Year	January	February	March	April	May	June	July	August	September	October	November	December	Year
1923	−1,145	−859	−645	−419	+646	+311	+58	−1,179	−1,086	−73	−648	−248	−5,278
1924	+286	+289	+160	+675	−766	−1,867	+1,590	+740	−1,355	+1,549	−467	−640	−6
1925	−413	−721	+35	+98	+060	+979	+35	+1,176	−574	−2,373	−175	+28	−959
1926	−14	−1,176	+1,099	+784	+2,072	−1,071	−847	−2,910	−1,827	−959	−700	−917	−6,475
1927	−686	−1,001	−2,079	−1,064	−2,772	−105	+77	−1,260	+406	+452	−690	+307	−8,415
1928	+112	+77	+245	−1,050	+56	−972	+1,764	−1,032	−1,701	+672	+364	−245	−1,740
1929	−217	+1,162	−854	−1,288	+532	+1,274	+2,541	+2,002	+637	+511	−308	−219	+5,773
1930	−742	+119	+413	−161	+2,443	+777	−1,216	+3,045	+1,281	+2,681	−455	+222	+8,405
Means	−352	−273	−203	−303	+397	−84	+500	+72	−527	+308	−382	−214	−1,087
Departures	−8%	−4%	−2%	−3%	←		+0.1%			→	−6%	−5%	

ATMOSPHERIC DUST AND VISIBILITY

In the paper of June, 1925, already referred to, it was shown that the product

$$D \times N \times R.\ H.$$

approximates to a constant, C, where
D = distance in miles to the most distant object that can be seen, N[1] = the number of dust particles per cubic centimeter, and $R.\ H.$ = the relative humidity expressed as a percentage.

A recomputation of the data there given for $D=10$ miles or more, and applying weights corresponding to the number of observations, gives 444,000 for the value of C.

A summary of dust and visibility measurements made between May, 1925, and June, 1931, inclusive, and given in Table 3, gives for the weighted mean value of C corresponding to visibilities in excess of 25 miles, 432,000, or approximately the value found from earlier observations. For shorter distances of visibility C has increased in value by from 50 to 100 per cent.

This is interpreted to mean that the local dust cloud has so little extent that it does not materially interfere with the visibility of prominent objects at moderate distances, while the most distant objects still require the most favorable conditions to be distinguished.

TABLE 3.—*Relation between atmospheric dustiness and visibility of distant objects*

SUMMER					WINTER				
Number of observations	N=dust particles per cubic centimeter	$R.\ H.$, per cent	D=visibility, miles	$C=D\times N\times R.\ H.$	Number of observations	N=dust particles per cubic centimeter	$R.\ H.$, per cent	D=visibility, miles	$C=D\times N\times R.\ H.$
35	155	62	40.4	388,000	19	158	62	33.3	331,000
108	253	69	27.5	480,000	15	250	54	34.7	468,000
114	353	65	24.2	555,000	34	198	59	33.9	366,000
123	445	70	20.1	626,000	21	362	64	25.4	588,000
100	556	68	20.7	783,000	28	448	66	24.8	733,000
119	647	70	16.0	725,000	35	553	65	21.0	755,000
95	751	75	15.8	847,000	49	652	69	20.0	900,000
118	851	72	12.1	741,000	26	751	67	18.4	926,000
69	943	72	11.8	801,000	48	857	60	16.0	823,000
91	1,075	78	9.2	788,000	35	943	67	13.3	840,000
62	1,311	77	7.5	757,000	58	1,091	70	10.1	771,000
33	1,641	74	5.4	656,000	54	1,341	74	8.9	883,000
6	2,636	79	8.0	1,666,000	56	1,704	71	6.6	799,000
					38	2,446	75	3.8	703,000
					9	3,595	85	2.1	642,000

A copy of the dust counts made at the American University, District of Columbia, is mailed each month to Dr. J. S. Owens, London, England, superintendent of observations, investigations of atmospheric pollution, department of scientific and industrial research. In a letter received after this paper was completed Doctor Owens transmits the following results of his study of the observations for the year April, 1930–March, 1931. The equation that he developed seems to give with considerable accuracy the relation between N, $R.H$, and V ($V=D$ of this paper). He says:

Visibility and wind velocity are given in the returns sent in, and an attempt has been made by examining the whole of the figures for the year to find some relation between visibility, number of suspended particles, and relative humidity. The result obtained is indicated in the curve (fig. 1) given below:

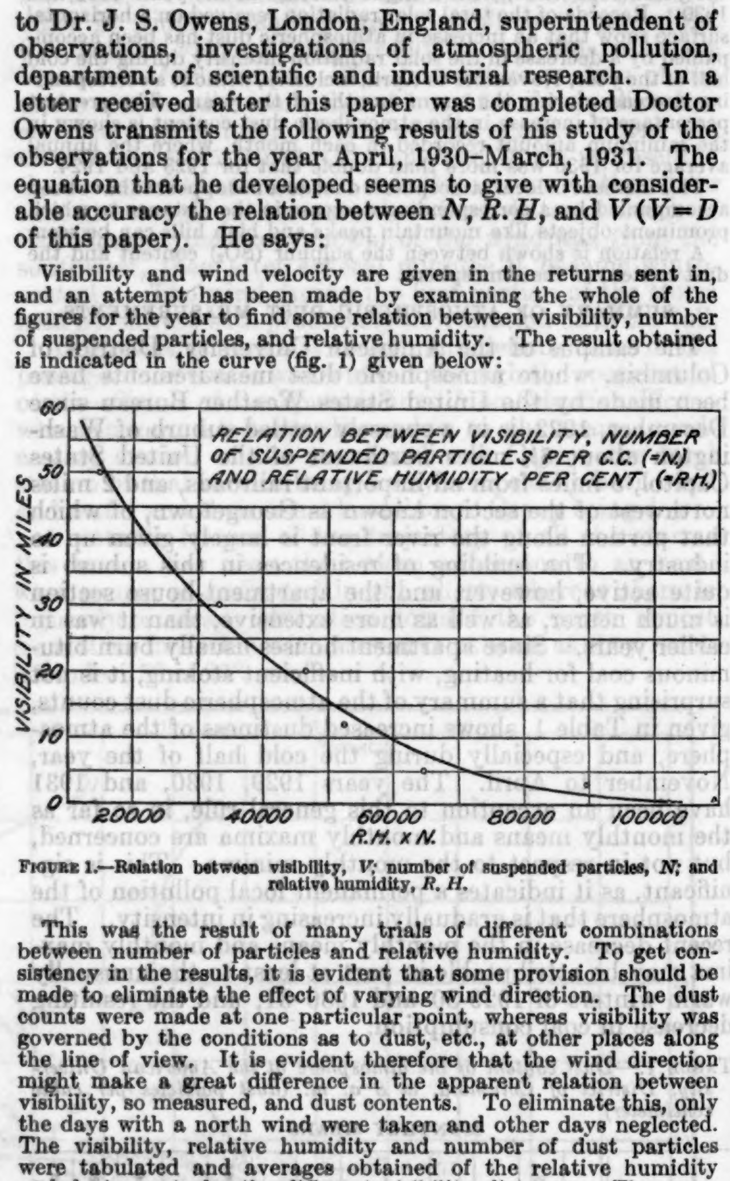


FIGURE 1.—Relation between visibility, V; number of suspended particles, N; and relative humidity, $R.\ H.$

This was the result of many trials of different combinations between number of particles and relative humidity. To get consistency in the results, it is evident that some provision should be made to eliminate the effect of varying wind direction. The dust counts were made at one particular point, whereas visibility was governed by the conditions as to dust, etc., at other places along the line of view. It is evident therefore that the wind direction might make a great difference in the apparent relation between visibility, so measured, and dust contents. To eliminate this, only the days with a north wind were taken and other days neglected. The visibility, relative humidity and number of dust particles were tabulated and averages obtained of the relative humidity and dust counts for the different visibility distances. The curve given (fig. 1) is for visibility plotted against the product of relative humidity and the number of dust particles.

The wind velocity is not taken into account in this curve because it appeared reasonable to assume that it was one of the factors governing the number of particles and was therefore already taken account of in the figure for the number of particles per cubic centimeter. The curve is remarkably smooth and agrees well with the equation

$$V=340-69 \log (RH \times N)$$

where V=visibility in miles, RH=relative humidity, and N= number of particles per cubic centimeter.

[1] This N must not be confused with N=the number of nuclei of condensation found by the use of the Aitken dust counter.

This is not quite the same as the equation evolved by Doctor Kimball (see the Review for June, 1925, 53:243), in which he gives the visibility in terms of the relative humidity and number of particles as—

$$V = \frac{390{,}000}{RH \times N} \text{ (approx.)}$$

It seems probable that any expression for visibility of this form would break down when approaching the point of saturation of the air, as in this neighborhood, apart from the effect of special pollution by hygroscopic salts, we might expect a rather sudden loss of visibility rather than a gradual one.

Since to obtain this curve (fig. 1) only days with a north wind were taken, it is not to be expected that the equation will apply when the wind is not north. Indeed, we can not hope for any general expression relating to dust count, relative humidity, and visibility until and unless we know the conditions along the line of vision. It would appear, however, that, knowing these conditions, there is good ground for believing that a simple relation might be established.

MEASUREMENTS OF THE SULPHUR (SO_2) CONTENT OF THE ATMOSPHERE

Method of measurement.—Equal quantities of a solution of distilled water, iodine, potassium iodide, and soluble starch were placed in two 20-liter bottles, each bottle being tightly sealed but provided with a ground-glass stopcock. The pressure within one bottle was reduced to one-half of the current atmospheric pressure, the stopcock closed, and the bottle was then shaken vigorously in order to have the liquid wash around the entire interior glass surface, and then the stopcock opened, the bottle being vigorously shaken until normal atmospheric pressure was resumed inside of it. The liquid in the comparison bottle was also similarly shaken, but the air was not disturbed within this bottle, a detail merely to approximate similar conditions in the two bottles.

The liquids in the two bottles were than placed in titration bottles; and if the tint of blue in each bottle was the same, no indication of the presence of sulphur evidenced itself. If, however, the tints differed, simple titration methods with the use of potassium iodide and other simple chemicals were resorted to in order to bring them to the same tint of blue.

Table 4.—*Dust particles per cubic centimeter and volumetric sulphur content of the atmosphere in parts per million*

Day of month	1926 November Dust	1926 November Sulphur	1926 December Dust	1926 December Sulphur	1927 January Dust	1927 January Sulphur	1927 February Dust	1927 February Sulphur	1927 March Dust	1927 March Sulphur	1927 April Dust	1927 April Sulphur
1	718	0	1,046	0.20	......	......	1,667	0.30	1,436	0.10	145	0.10
2	519	T.	145	0	......	......	519	T.	1,044	T.	260	0.15
3	1,529	0.20	1,756	0.85	1,730	0.40	1,000	0.10	166	0	......	......
4	853	0.05	1,558	0.50	676	0.15	1,243	0.25	187	T.	781	T.
5	781	0.40	......	......	807	0.25	239	T.	1,027	0.20	607	0.45
6	1,044	0.90	676	0	729	0.10	......	......	......	......	1,193	0.20
7	......	......	918	0.35	859	0	1,462	0.15	1,147	0.30	155	0
8	250	0.35	1,126	0.20	781	0.25	[1] 1,831	0.20	414	0	498	0.10
9	225	0.40	1,453	0.10	......	......	1,777	0.40	1,625	0.40	149	T.
10	76	0	901	0.35	895	0.60	2,474	0.65	1,201	0.55	......	......

[1] Additional data for Feb. 8:

Time	Dust, particles per cubic centimeter	Sulphur, parts per million
10 a. m.	2,470	0.95
11 a. m.	2,066	0.45
Noon	790	0.10
1 p. m.	607	T.
2 p. m.	680	0.25
3 p. m.	1,216	0.40

Table 4.—*Dust particles per cubic centimeter and volumetric sulphur content of the atmosphere in parts per million*—Continued

Day of month	1926 November Dust	1926 November Sulphur	1926 December Dust	1926 December Sulphur	1927 January Dust	1927 January Sulphur	1927 February Dust	1927 February Sulphur	1927 March Dust	1927 March Sulphur	1927 April Dust	1927 April Sulphur
11	365	0.10	498	0.20	584	0.35	1,426	T.	1,877	0.70	991	0
12	779	0.10	......	......	1,243	0.70	2,234	0.60	376	0.30	353	0.10
13	1,256	0.75	1,457	0.10	603	0.85	......	......	......	......	1,457	0.25
14	......	......	781	0.25	187	0.10	223	T.	145	0	571	T.
15	288	0.15	1,111	0.15	785	0	834	0.25	972	0.20	983	0.10
16	90	0	727	0	......	......	1,348	0.40	1,256	0.30	498	T.
17	844	0.10	1,653	0.35	985	0.20	197	T.	1,672	0.85	......	......
18	781	0.60	521	0	3,072	1.60	376	0.10	496	T.	1,046	0.15
19	1,001	0.35	......	......	1,359	0.45	523	0.20	1,130	0	1,529	0.30
20	1,518	0.55	2,024	0.45	607	0.60	......	......	......	......	729	0.10
21	......	......	[2] 2,388	0.70	351	0.40	1,676	T.	823	0.35	225	0
22	781	0.40	344	1.25	155	0.15	......	......	622	0.40	106	0
23	916	0.65	834	0.75	......	......	1,151	0.20	1,310	0.15	386	T.
24	1,646	2.65	1,546	......	773	0.65	365	0.10	586	T.	......	......
25	......	......	......	......	1,947	0.50	1,567	0.75	1,182	0.10	580	0
26	[3] 3,975	3.10	......	......	651	0.10	185	0	922	T.	970	0.10
27	143	T.	1,319	0.80	260	0	......	......	......	......	1,457	0.25
28	......	......	309	0	3,511	0.45	1,348	T.	676	0.15	130	0
29	521	0.40	628	0.20	1,044	0.15	......	......	918	0	1,319	0.10
30	370	0.10	386	0.45	......	......	......	......	1,252	0.20	1,558	0.15
31	......	......	1,359	0.65	586	T.	......	......	886	0.10	......	......

Day of month	1927 May Dust	1927 May Sulphur	1927 June Dust	1927 June Sulphur	1927 July Dust	1927 July Sulphur	1927 August Dust	1927 August Sulphur	1927 September Dust	1927 September Sulphur	1927 October Dust	1927 October Sulphur
1	......	......	475	0	464	0	1,443	T.	1,424	0.05	796	0
2	229	0.05	897	0	918	0	300	0	813	T.	......	......
3	674	0.15	678	0	......	......	1,044	T.	......	......	1,210	0.05
4	596	0.20	1,436	0	......	......	1,098	T.	......	......	99	0
5	622	0	......	......	1,006	0.20	918	0	......	......	680	T.
6	1,516	T.	149	0	624	0	622	0	374	0	1,252	0.10
7	899	0.10	674	0.15	1,204	T.	......	......	970	0	970	0.05
8	......	......	307	0	806	T.	1,239	0	1,651	0	307	T.
9	271	0.20	603	0	834	0	674	0	288	0.05	......	......
10	727	0	865	T.	......	......	288	0	708	0	1,193	0.15
11	603	0	1,147	T.	731	0	708	0	......	......	1,525	0.20
12	806	0.10	......	......	1,128	0	1,004	0.05	374	0	918	0.10
13	246	0	143	0	922	T.	1,233	T.	1,042	0	225	0
14	353	0	603	0.05	353	0.10	......	......	1,518	0.05	813	T.
15	......	......	729	T.	1,457	0	225	0	983	T.	[4] 3,133	2.40
16	225	0	164	T.	288	T.	781	0	781	T.	......	......
17	269	0	813	0.20	......	......	1,233	0	1,193	0.10	1,646	0.25
18	1,529	0	888	0	1,037	0	187	0	......	......	286	0
19	1,252	0	......	......	918	T.	225	0	407	0	162	0
20	422	0	[5] 271	0.15	785	0.10	1,004	T.	353	0	307	0
21	1,466	0.10	832	T.	1,006	0	......	......	416	0	363	0
22	......	......	256	0.20	1,338	0.15	1,214	0.05	218	0	790	0
23	1,138	0	584	0	601	0.10	229	0	496	0	......	......
24	496	0	1,560	T.	......	......	435	0	1,214	T.	1,518	0.35
25	928	0.15	441	T.	1,006	T.	225	0	......	......	1,042	T.
26	458	0	......	......	1,046	0	804	T.	1,518	0.05	601	0.15
27	386	0	122	0	781	0	1,252	0	1,672	0.05	1,552	0.20
28	624	0	363	0	1,426	0.05	......	......	790	0.10	1,346	0.15
29	......	......	218	0	993	T.	498	0	813	0.05	1,840	0.25
30	......	......	554	T.	1,651	0.10	645	0	601	0	......	......
31	1,483	0.15	......	......	......	......	991	0	......	......	1,976	0.15

Day of month	1927 November Dust	1927 November Sulphur	1927 December Dust	1927 December Sulphur	1928 January Dust	1928 January Sulphur	1928 February Dust	1928 February Sulphur	1928 March Dust	1928 March Sulphur	1928 April Dust	1928 April Sulphur
1	1,000	T.	498	0	......	......	1,784	0.20	1,443	0.10	......	......
2	......	......	970	T.	......	......	729	0	680	0	1,155	0
3	435	0.10	269	0	1,672	0.20	2,070	0.25	943	0.10	966	0
4	601	0	......	......	825	T.	1,768	0.20	......	......	2,039	0
5	905	0	166	0	1,000	T.	......	......	441	T.	695	0.40
6	......	......	393	T.	1,243	0.05	1,042	0.10	2,617	0.55	907	0
7	1,105	0.10	1,436	0.25	1,651	0.10	3,511	0.90	2,188	0.40	699	0
8	1,661	0.40	676	T.	......	......	970	0	1,672	0.20	......	......
9	1,911	0.10	363	0.05	1,730	0.20	813	0	2,020	0.95	878	0
10	2,566	0.55	838	0.25	2,184	0.45	1,453	0.15	622	0.10	645	0
11	1,621	0.20	......	......	689	0.10	622	0	......	......	475	0.20
12	603	0	1,394	0.20	985	T.	......	......	2,190	0.80	252	0.30
13	......	......	2,043	0.35	2,961	0.50	2,358	0.35	1,831	0.65	177	0

[2] Dense smoke cloud enveloped university this date; 4,502 particles of dust per cubic centimeter at 1:30 p. m.

[3] Much soot.

[4] Haze in west; local smoke with noticeable sulphur odor.

[5] Spores.

TABLE 4.—*Dust particles per cubic centimeter and volumetric sulphur content of the atmosphere in parts per million*—Continued

Day of month	1927				1928							
	November		December		January		February		March		April	
	Dust	Sulphur	Dust	Sulphur	Dust	Sulphur	Dust	Sulphur	Dust	Sulphur	Dust	Sulphur
14	1,182	0.10	145	0	1,558	0.10	2,066	0.20	2,386	1.30	178	0
15	884	T.	1,831	0.40			254	0	405	0		
16	2,512	0.45	2,508	1.10	2,297	0.55	1,665	1.10	2,402	0.35	418	0
17	1,420	0.20	143	0	1,042	0.20	1,348	0.25	1,764	0.20	1,533	0
18	359	0			1,667	0.40	727	0.80			456	0.25
19	172	0	496	T.	2,176	0			164	0	1,321	0
20			796	0.45	313	0	1,651	0.10	557	0	1,533	0.10
21	970	0	1,651	0	729	0	1,350	0.20	953	0.20	2,039	T.
22	783	0	521	0.35			983	0.30	689	T.		
23	1,203	0	1,453	0.20	943	0	1,825	0.10	556	0	1,113	0.45
24					2,251	0.20	689	0	882	0	867	0.40
25	811	0			160	0	1,432	0.20			174	0
26	1,940	0			1,539	0.10			1,853	0.10	672	0
27			2,253	0.15	899	0.10	832	0	376	0	894	0
28	374	0	2,795	0.60	183	0	804	0.25	1,764	0.20	252	0.20
29	916	0	1,037	0.20			3,557	1.20	1,809	0.10		
30	403	0.10	1,646	0.30	3,620	0.65			170	0	1,073	0
31			2,984	0.50	2,050	0.15			162	0		

Day of month	1928											
	May		June		July		August		September		October	
	Dust	Sulphur	Dust	Sulphur	Dust	Sulphur	Dust	Sulphur	Dust	Sulphur	Dust	Sulphur
1	966	0	569	0			628	0			334	0.20
2	490	0	964	0.20	384	0	655	0			1,485	1.15
3	981	0			865	0	196	0			1,401	0.25
4	1,163	T.					403	0			655	0.40
5	1,575	0	376	0.10	1,107	0.25					672	0.20
6			275	0	420	0	563	0	437	0	796	0.45
7	811	0	914	0.10			846	0.15	731	0		
8	315	0	1,434	0.25			1,151	0.20	632	0.15	1,308	0.65
9	126	0.10	594	0			571	0.30			1,401	0.30
10	336	T.					790	0	1,493	0.25	687	T.
11	934	0	1,132	T.			359	0.45	286	0	1,258	1.60
12	134	0	286	0.15	1,308	0.20			571	0.20	830	0.40
13			605	0.25	1,014	0.10	132	0	1,092	0.30	1,199	0.55
14	821	0	202	0	386	0.30	527	0	302	0		
15	351	0	655	0			586	0	832	0.10	2,163	1.50
16	494	0.10	722	0	586	0	701	0.10			1,596	1.10
17	1,006	0.25			628	0	773	0	1,294	0.40	2,772	1.75
18	216	0.35	788	0	386	0	655	0	1,159	0.30	1,888	0.65
19	502	0.20	336	0.10	821	0			361	0	788	T.
20			907	0.20	947	0	1,117	0.25	126	0	351	0
21	620	T.	202	0.10	672	0.10	1,302	0.35				
22	603	0	410	0			437	0			998	0.20
23	1,210	0.25	426	0.15	727	0.10	672	0			1,258	0.45
24	294	0			865	0	899	0.10	861	0.25	739	T.
25	403	0.35	206	0	722	0	662	0	1,064	0.35	840	0.25
26	235	0.10	972	0.15	1,049	0			880	0.30	393	0.20
27			594	0	714	0	907	0.25	1,453	0.90	628	0.35
28	1,006	0.25	588	0	861	0	594	0.30	586	0.20		
29	888	0.10	458	0.05			351	0	538	0.55	697	0.60
30			284	0	470	0	626	0			872	0.55
31	437	0			[a]972	1.20	1,109	0.40			1,210	0.75

[a] Haze.

Table 4 gives the daily sulphur measurements, together with the determination of the dust content of the atmosphere. The two measurements were made at the same place and the sulphur determinations followed immediately the dust measurements.

Table 5 summarizes the atmospheric sulphur determinations. From May to August, inclusive, on at least half the days on which determinations were made, not a trace of sulphur was found, and from April to September, inclusive, on more than half the days the amount present was not measurable (T. or 0). Also, from April to August, inclusive, the measured amount did not exceed in volume 0.45 parts per million, and in the majority of cases it did not exceed 0.2.

An amount in excess of one part per million in volume was measured on only 15 days out of the 600 on which measurements were made. Five of these days were in October, 1928, and were accompanied by an unusual number of dust particles, which quite probably came from a furnace that was being operated by the nitrate fixation laboratory on the American University campus to reduce certain rock material for the purpose of extracting phosphoric acid and potash. Eight of the remaining ten days with much sulphur were also days with many dust particles, the maximum of sulphur, 3.1 parts per million, on November 26, 1926, having as its accompaniment 3,975 dust particles per cubic centimeter. October 15, 1927, with 2.4 parts of sulphur per million had 3,133 dust particles per cubic centimeter, and there was a noticeable odor of sulphur from local smoke. December 22, 1926, with 1.25 parts of sulphur per million had only 344 dust particles per cubic centimeter, but it was raining at the time, and this would have a tendency to precipitate local dust from the lower atmospheric layers. On July 31, 1928, with 1.2 parts of sulphur per million, only 972 dust particles per cubic centimeter were collected by the Owens jet dust counter, but a note states that there was a dense haze, with the wind from the south. Such a wind would bring smoke from the industrial section of Georgetown.

The chemical process used in measuring atmospheric sulphur records in units of 1 part in 20,000,000 by volume, while it is generally conceded that 2 parts in a million is noticeable by its sulphur odor to the average individual.

TABLE 5.—*Summary of atmospheric sulphur determinations*

Parts per million	Average monthly occurrences											
	November	December	January	February	March	April	May	June	July	August	September	October
0	7.5	5.5	4.5	4.0	7.5	11.0	14.0	12.5	12.5	17.5	9.0	4.5
T.	2.0	2.0	2.0	3.5	3.0	3.0	2.0	4.5	3.5	3.0	2.0	3.5
0.05 to 0.20	7.0	6.0	9.0	8.0	8.5	7.0	7.0	7.5	5.5	3.0	6.0	7.0
0.25 to 0.45	4.0	6.5	4.5	5.0	4.0	4.5	2.5	1.0	1.0	3.5	3.5	5.5
0.50 to 0.95	3.0	4.0	4.5	2.5	3.5	0	0	0	0	0	1.0	3.0
1.00 or more	1.0	1.0	0.5	1.0	0.5	0	0	0	0.5	0	0	3.0
Average number of days	24.5	25.0	25.0	24.0	27.0	25.5	25.5	25.5	23.0	27.0	21.5	26.5

These sulphur determinations were made at the request of the United States Bureau of Standards. They constitute a link in a series of tests made in cooperation with the International Nickel Co. in a study of the durability of wire screens under different conditions. Measurements made in Pittsburgh represented conditions in an industrial city. Measurements at the navy yard, Portsmouth, Va., represented seacoast conditions, where the atmosphere contains many salt crystals. The campus of the American University, District of Columbia, was expected to approximate open-country conditions.

VIOLENT LOCAL STORM IN NEVADA, JULY 24, 1931

By J. R. FULKS

[Weather Bureau Office, Winnemucca, Nev., August 10, 1931]

An intense storm, resembling a small tornado, occurred at the Leonard Creek ranch, Humboldt County, Nev., at about 1 p. m. (one hundred and twentieth meridian time) on July 24, 1931. This ranch is about 70 miles northwest of Winnemucca and at about 118° 47′ W., 41° 30′ N.

The scene of the storm was visited two days later by Mr. Smith, official in charge at Winnemucca, and myself.

The Leonard Creek ranch is located in a narrow canyon which opens into the northern edge of the Black Rock Desert, a level arid region about 60 miles long and 15 to 20 miles wide. The country immediately surrounding the ranch is mostly low hills with rather high mountains rising a few miles to the north.

This storm appeared to have a whirling motion, as described by Mr. Ramon Montero, one of the ranch owners, and was of considerable violence along a short and very narrow path.

The storm, while of little significance when compared to local storms, occurring in the middle western and southern portions of the United States, deserves mention because of the infrequency of such in this vicinity, and also because it occurred on the same day as a thunderstorm, which, as observed at Winnemucca, showed cold-front characteristics. It is also worthy of mention that it happened during the period of warmest weather of record in the middle Plateau region.

We are able to find a record of only two tornadoes (or those so classified) in Nevada hitherto. One of these was at Winnemucca on December 16, 1879, the other at Fallon on April 29, 1915.

Mr. Montero describes the whirl as originating on or near a small conical peak about 500 yards west of the ranch buildings. Its development is given as accompanied by a single dark cloud and a few claps of thunder; the general appearance of the sky as clear except for a few other scattered clouds and a thunderstorm which appeared to be passing over the mountains to the north. Temperature is described as being excessively warm before, and slightly cooler after, the storm; and wind, both before and after, as very light. A better description of the appearance could not be obtained, as Mr. Montero explained that the excitement incident to getting himself and family to a place of safety made a more accurate observation impossible.

The whirl apparently moved in a curved or irregular path, as the only building destroyed is east of the place where it was first observed, and at the point of damage the storm moved toward the northeast. The exact place at which it dissipated could not be determined, but débris is scattered for only about one hundred yards, and no evidence of it is visible further than that. Land in that direction is covered with sagebrush. The total distance traversed was, therefore, as near as could be determined, about 600 yards. Its width is estimated at 50 feet.

A small narrow lambing shed about 50 feet long, substantially constructed of heavy timber, was completely destroyed. A larger building adjoining it to the west and apparently no more substantial was not damaged. A garden is to the east of the shed, and while Mr. Montero says some of the vegetables were uprooted, but little damage was apparent. Timber of the building, broken down but still hanging, leaned toward the north. A small schoolhouse about 75 feet to the north, located within the edge of a grove of trees, was not damaged. A hay wagon, standing between the two buildings and about 25 feet from the schoolhouse, was moved eastward a distance of 200 feet, where it was left undamaged. Mr. Montero believes that this was picked up completely from the ground. No evidence of its being moved along the surface could be found except within a few feet of the place it was left after the storm. Had it moved over the surface, the tongue, which hung loose, should have left a visible mark. Very little damage was done to the grove of trees; a few broken branches left hanging were twisted at the point broken, and some débris was caught in the trees.

No data were obtainable on the rate of movement, except that Mr. Montero says it seemed to come up and was over in an instant. Also the direction of whirl could not be determined.

Mr. Montero estimated damage to the building at $1,500. No one was injured.

The weather map on the morning of July 24 shows a trough of low pressure over California and Arizona, axis northwest and southeast, and a ridge of high pressure extending southeastward from the mouth of the Columbia River into northern Nevada. The following morning shows the trough less marked, and pressure gradients over the remainder of the country very weak, with the ridge of high pressure in the Northwest no longer noticeable. Very light precipitation occurred during the 24 hours over a narrow strip extending from northern Nevada to southeastern Wyoming.

A thunderstorm began at Winnemucca at 6.46 p. m. of the 24th; rain began at 6.50 p. m. and ended at 9.15 p. m., with total precipitation 0.12 inch. Wind from 2 p. m. to 7 p. m. was from the northwest. During the first hour of the storm south wind prevailed, during the second hour east, and thereafter northeast throughout the night. The maximum velocity was 31 miles per hour from the south at 7 p. m. The pressure rose 0.15 inch from 7 to 9 p. m., then fell 0.03 inch, rose 0.03 inch, and remained stationary throughout the rest of the night. The temperature dropped from 92° at 6.45 p. m. to 69° at 8 p. m. The direction of movement of the storm appeared to be eastward. This thunderstorm differed from most others at this station in that it showed a slightly greater and more permanent pressure rise, and light continuous precipitation for a longer period of time.

ON THE UNIFORMITY OF SYMBOLS USED IN PUBLICATIONS ON ACTINOMETRY

By ANDERS ÅNGSTRÖM

[Statens Meteorologisk-Hydrografiska Anstalt, Stockholm, Sweden]

The attention of the present author was at first drawn to this matter by Doctor Dobson, who pointed out in a letter the confusion existing as regards symbols, the same symbol being sometimes used even in the same paper for indicating different quantities.

In fact a certain uniformity seems here desirable and also possible to obtain.

As a preliminary step before the matter can be discussed by an international body, I have consulted a number of scientists working in the field of actinometry, and especially I have asked for the opinions of the Meteorological Institute at Potsdam through Doctor Süring, and also for those of Doctor Kimball, formerly president of the radiation commission of the I. G. G. U.

Before giving his own view on the matter, Doctor Kimball refers to the fact that opinions have been expressed against "trying to standardize symbols for actinometric factors, for the reason that we can not get letters that are not already used to indicate factors in some branch of the physical sciences." "Each author should state specifically the meaning of the symbols he employs."

As regards the desirability of stating in each separate case the meaning of the symbols employed, I think there is no diversity of opinion. A certain uniformity will not make such a statement superfluous. But on the other hand I can not attach great weight to the objection that all symbols are already used in some other branch of physical sciences. As natural as it seems that the same author ought to try to use in his various papers the same symbols for the same factors, as reasonable seems also the demand that we ought to aim at a certain uniformity also among various authors.

It is evident that a proposal as regards uniformity of symbols ought not to aim at an alteration of the symbols which are already in use in periodical publications like the Annals of the Astrophysical Observatory, for instance, where a certain uniformity is already created. But the proposal aims at trying to introduce uniformity in all these cases of separate papers and articles, where the lack of uniformity arises simply from the lack of cooperation and accepted rules.

The matter may be regarded as one of inferior importance. And yet it is of considerable weight, just for making ourselves rid of small obstacles in order to have opportunity to concentrate upon the large ones.

As regards some symbols the opinions have gone in various directions. I do not propose to discuss them here. In the following cases however, the opinions seem in general to agree:

1. Intensity of sun radiation $= I$.
   (a) Solar constant $= I_0$.
   (b) Sun radiation within certain spectral intervals: I_r, I_g, $I_{\lambda=540}$, etc.
2. Relative air mass (zenith air mass taken as unit) $= m$.
3. True air mass $= M$; $\left(M = m\dfrac{b}{760}\right)$ where b is the barometric pressure at the place of observation.
4. (a) h = height of the sun.
   (b) z = zenith distance of the sun.
5. R = effective radiation of long-wave length (generally measured as nocturnal radiation).
6. D = Diffused radiation from the sky.
7. G = atmospheric long-wave radiation.

$$G = \sigma T^4 - R$$

where σ is the constant of Stefan-Boltzmann and T is the absolute temperature.

For the cases where no conflict arises with indications generally accepted for other physical factors, I therefore propose that these symbols be generally used. Especially I have in mind the publications of the observations during the International Polar Year 1932-33.

RETIREMENT OF H. A. HUNT, GOVERNMENT METEOROLOGIST OF AUSTRALIA

A circular, recently received from Melbourne, announces the retirement on February 6, 1931, of H. A. Hunt, Commonwealth meteorologist for Australia.

Mr. Hunt was born in London in 1866. In 1884 he joined the Sydney Observatory staff He was the inventor of the cube pressure anemometer (1902). In 1906 he was made Commonwealth meteorologist, which position he held up to his retirement. Among his published works may be mentioned Types of Australia Weather (1893), and in the succeeding years numerous papers on the climate of Australia.

Mr. Hunt was succeeded by William Shand Watt.—*H. L.*

BIBLIOGRAPHY

C. FITZHUGH TALMAN, in charge of Library

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Alessandri, Camillo.
Geofisica; meteorologia, aerologia e pireliometria. Bologna. [1931.] xix, 565 p. diagrs. 31½ c. (Spedizione italiana de Filippi nell' Himàlaia, Caracorum e Turchestan cinese (1913–1914). [Relazioni scientifiche]. Ser. I. Geodesia e geofisica. vol. 3.)

Bigelow, Henry Bryant.
Oceanography; its scope, problems, and economic importance. Boston. 1931. 262 p. 21 cm.

Clyde, George D.
Snow-melting characteristics. Logan. n. d. 48 p. illus. 23 cm. (Utah agric. exp. sta. Bull. 231 (Tech.). Aug., 1931.)

Gavilan, Alfonso Reyes.
Compendio sobre los ciclones tropicales . . . Habana. 1930. 30 p. 19½ cm.

Heyde, Gustav.
Recording balloon theodolite. p. 36–37. illus. 27½ cm. (Instrument world. v. 4, June, 1931.)

Italy. Ufficio presagi.
I principali tipi isobarici interessanti l'Italia (quinquennio 1926–1930). Roma. 1931. 11 p. plates (fold.) 23 cm.

Jaumotte, J.
Sur l'anémomètre de Robinson. 4 p. fig. 27½ cm. (Cong. nat. des sci.)

Koch, J. P., & Wegener, A.
Wissenschaftliche Ergebnisse der dänischen Expedition nach Dronning Louises—Land und quer über das Inlandeis von Nordgrönland 1912–13 unter Leitung von Hauptmann J. P. Koch. København. 1930. Abt. 1–2. illus. plates (fold.) 28½ cm. (Meddelelser on Grønland. Bd. 75. 1–2 Afd.)

Lewis, W. W., & Foust, C. M.
Direct strokes to transmission lines. p. 452–458. illus. 30½ cm. (Gen. elec. rev., v. 34, no. 8. Aug., 1931.)

Lugeon, Jean.
Rapport général sur la question des relations entre les précipitations atmosphériques, le débit et l'évaporation. 13 p. 23½ cm. (Compte rendu des trav. III–ème confér. hydrol. des États balt. tenue à Warszawa en mai 1930. Warszawa. 1931.)
Réflexions sur les méthodes d'investigation en hydrométéorologie. Warszawa. 1930. 15 p. fig. 23½ cm. (III-ème confér. hydrol. des États balt. Warszawa. mai 1930.)
Remarques sur la participation de la Pologne à l'année polaire 1932/33. Warszawa. 1931. 4 p. 24 cm. (Bull. soc. géophys. de Varsovie. Pub. trimes. 1931. I. fasc.) [Author, title, and text in Polish and French.]

Lundegårdh, Henrik Gunnar.
Environment and plant development being "Klima und Boden in ihrer Wirkung auf das Pflanzenleben" . . . trans. & ed. from the 2nd German edition, by Eric Ashby . . . London. 1931. xii, 330 p. illus. (incl. maps). pl. diagrs. 23½ cm.

McAdie, Alexander.
Airgraphics. Cambridge. 1931. 37 p. diagr. front. 30 cm.

Mares, David J.
Know your own weather; popular studies in Australian meteorology. Sydney. 1930. 7,138 p. front. illus. maps. diagrs. 19 cm. Bibliography: p. [131].

Negretti & Zambra.
Standard meteorological instruments. [Bolton. 1931.] 140 p. illus. 25½ cm. (List M. 2.)

Ray, C. L.
Tipos frecuentes de las condiciones del tiempo en San Juan de Puerto Rico. p. 185–189. 30 cm. (Rev. de obras pub. de Puerto Rico. Año 8, no. 8, Ago. 1931.)

Schmitt, Wilhelm.
Föhnerscheinungen und Föhngebiete. Innsbruck. 1930. 64 p. figs. plates (part fold.) 28 cm. (Wissensch. Veröffent. des D. u. Oe. Alpenvereins. 8.)

Smith, Edward H.
Arctic ice, with especial reference to its distribution to the North Atlantic ocean. Washington, 1931. x, 221 p. illus. 23½ cm. (U. S. Coast guard. Bull. no. 19. Marion exped. to Davis Strait and Baffin Bay under the direction of the U. S. Coast Guard. 1928. Sci. results. pt. 3.)

SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS DURING SEPTEMBER 1931

By HERBERT H. KIMBALL, Solar Radiation Investigations

For a description of instruments employed and their exposures, the reader is referred to the January, 1931, REVIEW, page 41.

Table 1 shows that solar radiation intensities averaged below the normal values for September at all three stations at which measurements of direct solar radiation at normal incidence are made.

Table 2 shows an excess in the total solar radiation received on a horizontal surface at New York, Pittsburgh, La Jolla, Fresno, Lincoln, and Chicago, close to the September average at Madison and Gainesville, and a deficiency at Washington and Twin Falls.

Skylight polarization measurements made on 5 days at Washington gave 56 for the mean percentage of polarization with a maximum of 64 on the 9th. At Madison, polarization measurements made on 11 days gave a mean of 61 per cent with a maximum of 71 per cent on the 11th. These are close to the corresponding averages for each station in September.

TABLE 1.—*Solar radiation intensities during September, 1931*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	Sun's zenith distance									
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass A. M.					Air mass P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Sept. 1	15.11		0.58	0.71							16.74
Sept. 4	12.68		0.58	0.71	0.93	1.29					9.16
Sept. 8	8.81	0.67	0.77	0.91	1.04	1.36					6.76
Sept. 9	11.81	0.65	0.78	0.92	1.02	1.19					12.68
Sept. 10	17.37			0.49	0.66	1.07	0.98	0.73	0.61		17.37
Sept. 11	18.59			0.46	0.77	0.98					19.89
Sept. 12	19.23			0.55	0.78	1.05					17.37
Sept. 14	16.20		0.71	0.79	0.98	1.31					17.96
Sept. 18	19.89					1.48					10.97
Sept. 19	10.21		0.63	0.77	0.97	1.24					10.59
Sept. 22	21.28			0.86	1.02	1.17					22.00
Sept. 25	6.27			1.13	1.26						7.57
Sept. 29	5.79	0.86	0.90	1.13	1.30	1.47	1.22				5.36
Sept. 30	8.48	0.61	0.73	0.90	1.09		1.05	0.81	0.71	0.56	8.18
Means		0.70	0.72	0.79	0.98	1.24	1.08	(0.77)	(0.66)	(0.56)	
Departures		+0.01	−0.03	−0.07	−0.06	−0.07	+0.03	−0.07	−0.06	−0.10	

[1] Extrapolated.

TABLE 1.—*Solar radiation intensities during September, 1931*—Con.

Madison, Wis.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Sept. 3	9.14					1.25					11.38
Sept. 4	12.24				1.23	1.43	1.23				9.83
Sept. 10	14.60			0.84	1.03	1.34	1.05				13.61
Sept. 11	15.65		0.74	0.88	1.06	1.22	0.97				14.60
Sept. 12	16.20		0.53	0.68	0.80	1.26					13.13
Sept. 14	16.20			0.70	0.86		1.09				17.96
Sept. 16	16.79					1.32	1.11				18.59
Sept 17	14.60						1.22				11.38
Sept. 22	14.60					1.28	1.18				14.10
Sept. 24	6.50		1.10	1.16	1.30						6.76
Sept. 28	7.29					1.51	1.14	1.03			6.76
Sept. 29	7.04		0.69	0.88	1.11	1.40					7.29
Means			0.76	0.86	1.06	1.33	1.12	(1.03)			
Departures			−0.14	−0.15	−0.09	−0.04	−0.03	+0.02			

Lincoln, Nebr.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
Sept. 3	11.81					1.26	0.98	0.77	0.61	0.42	14.10
Sept. 4	13.13		0.66	0.81	0.99	1.31	1.01	0.84	0.70	0.61	11.38
Sept. 5	14.10		0.73	0.88	1.09	1.31					16.20
Sept. 10	12.68			0.90	1.10	1.30					12.68
Sept. 11	14.35		0.75	0.89	1.09	1.38	1.07	0.92	0.79	0.66	13.61
Sept. 12	13.13		0.75	0.88	1.07	1.31	0.92	0.69			13.61
Sept. 16	11.81		0.88	1.01	1.15						15.65
Sept. 18	11.38						1.02				15.11
Sept. 22	8.81	0.84	0.96	1.10	1.27	1.43					10.59
Sept. 25	8.18			1.16	1.31	1.48					8.81
Sept. 26	7.04		1.01	1.20	1.34	1.52	1.31	1.16	1.01	0.92	8.18
Sept. 29	7.87	0.73	0.82	0.94	1.13	1.39					8.74
Means		(0.78)	0.82	0.98	1.15	1.37	1.05	0.88	0.78	0.65	
Departures		+0.02	−0.04	−0.02	−0.03	−0.03	−0.09	−0.09	−0.05	−0.08	

TABLE 2.—*Total solar radiation (direct+diffuse) received on a horizontal surface*

[Gram-calories per square centimeter]

AVERAGE DAILY TOTALS

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Pittsburgh	Gainesville	Fresno	La Jolla	Miami	New Orleans
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Sept. 3	400	453	507	350	399	422	401	423	515	335	441	433
Sept. 10	356	355	404	[1] 289	357	413	356	386	510	374	512	326
Sept. 17	310	249	326	[2] 316	306	321	363	[3] 502	506	367	488	312
Sept. 24	323	295	453	322	350	373	279	[4] 426	450	336	381	373

DEPARTURES FROM WEEKLY NORMALS

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Pittsburgh	Gainesville	Fresno	La Jolla	Miami	New Orleans
Sept. 3	+21	+81	+85	+36	+85	−98	+55	+13	−7	−14	...	
Sept. 10	−18	+9	−2	−6	+53	−79	+2	−31	+14	+55	...	
Sept. 17	−42	−90	−58	+39	+18	−140	+28	+53	+49	+43	...	
Sept. 24	−22	+4	+101	+82	+82	−57	−16	−22	+21	−14	...	
Accumulated departures on Sept. 30, 1931	−471	+3,143	+1,652	+217	+476	−5,788	−1,611	...	+339	−6,503	...	

[1] Mean for 4 days. [2] Mean for 6 days. [3] Mean for 5 days. [4] Mean for 4 days.

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, Superintendent United States Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, Perkins, and Mount Wilson observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Positions and areas of sun spots—Continued

Date	Eastern standard civil time		Heliographic: Diff. long.	Longitude	Latitude	Area: Spot	Group	Total area for each day
1931	h	m	°	°	°			
Sept 1 (Naval Observatory)	10	47	−41.0	345.5	+4.0	12		
			−12.5	14.0	+12.0		108	
			−1.5	25.0	+2.0	31		151
Sept. 2 (Naval Observatory)	10	43	−70.0	303.4	−6.0	3		
			+2.0	15.4	+11.5		93	
			+11.0	24.4	+2.0	31		127
Sept. 3 (Perkins Observatory)	10	22	+18.5	18.9	+9.0	93		
			+26.0	26.4	+1.5	93		186
Sept 4 (Naval Observatory)	10	45	−42.0	304.9	−6.0	9		
			+21.0	7.9	+11.0		25	
			+31.5	18.4	+10.0		31	
			+39.0	25.9	+2.0	31		96
Sept. 5 (Naval Observatory)	10	43	+46.0	19.7	+11.5	15		
			+51.0	24.7	+2.5	31		46
Sept. 6 (Naval Observatory)	10	41		No spots				
Sept. 7 (Naval Observatory)	10	41	+1.5	308.8	−5.5	9		9
Sept. 8 (Naval Observatory)	10	42	+16.0	310.1	−6.0	9		9
Sept. 9 (Naval Observatory)	10	43	−70.5	210.4	−20.0	6		
			−42.5	238.4	−9.5	31		
			+28.0	308.9	−7.5		25	62
Sept. 10 (Naval Observatory)	10	42	−28.3	239.4	−9.7	19		
			+42.0	309.7	−7.0		77	96
Sept. 11 (Naval Observatory)	10	42	−13.2	241.3	−9.2	12		
			+31.5	286.0	+8.7	31		
			+58.2	312.7	−8.0		123	166
Sept. 12 (Naval Observatory)	10	36	−3.0	238.4	+9.5		37	
			+71.0	312.4	−8.0		154	191
Sept. 13 (Naval Observatory)	10	36	−69.5	158.7	+3.0	6		
			+11.0	239.2	+9.0		62	68
Sept. 14 (Naval Observatory)	10	37	−56.0	159.0	+4.0		37	
			+24.8	239.8	+9.4		74	
			+55.0	270.0	+17.0	12		123
Sept. 15 (Naval Observatory)	13	36	−40.3	159.8	+3.3	31		
			+39.0	239.1	+9.0		87	118
Sept. 16 (Naval Observatory)	12	13	−73.0	114.7	+9.0		154	
			−26.5	161.2	+3.3	25		
			+51.0	238.7	+9.2		129	308
Sept. 17 (Naval Observatory)	12	27	−57.8	116.5	+8.6		93	
			−12.2	162.1	+3.0		12	
			+8.7	183.0	+19.9	15		
			+63.6	237.9	+8.2		74	194
Sept. 18 (Naval Observatory)	10	49	−45.0	117.0	+8.0		77	
			+75.0	237.0	+7.0	6		83
Sept. 19 (Naval Observatory)	10	42	−31.0	117.9	+8.0	68		68
Sept. 20 (Mount Wilson)	18	30	−36.0	95.4	+9.5	4		
			−13.0	118.4	+9.0		112	116
Sept. 21 (Naval Observatory)	10	37	−4.5	118.0	+8.1		50	50
Sept. 22 (Naval Observatory)	10	34	−14.0	95.4	+8.0		93	
			+9.0	118.4	+7.6		56	149
Sept. 23 (Naval Observatory)	10	16	0.0	96.3	+6.0		62	
			+22.0	118.3	+7.0	31		
			+37.0	133.3	−3.0	12		105
Sept. 24 (Naval Observatory)	10	40	+11.5	94.4	+5.5		31	
			+38.0	120.9	+7.5	19		50
Sept. 25 (Naval Observatory)	10	40	+50.5	120.2	+7.5	9		9
Sept. 27 (Naval Observatory)	10	35	−85.0	318.4	+8.7	62		
			−26.5	16.9	+4.5		12	
			−10.0	33.4	+6.5		15	89
Sept. 28 (Naval Observatory)	11	22	−75.0	314.7	+8.5		123	123
Sept. 29 (Naval Observatory)	10	44	−59.0	317.9	+18.5	123		
			−68.5	308.4	+18.5	46		169
Sept. 30 (Naval Observatory)	10	44	−53.5	310.2	+18.5	108		
			−45.0	318.7	+18.7	37		145
Mean daily area for September								107

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR SEPTEMBER, 1931

(Dependent alone on observations at Zurich and its station at Arossa)

[Data furnished through the courtesy of Prof. W. Brunner, University of Zurich Switzerland]

September, 1931	Relative numbers	September, 1931	Relative numbers	September, 1931	Relative numbers
1	33	11	29	21	*a* 10
2	*a* 27	12	M*c* 23	22	M*c* 22
3	27	13	27	23	22
4	19	14	26	24	16
5	15	15	*d* 19	25	7
6	15	16	27	26	7
7	14	17	28	27	15
8	18	18	26	28	*d* 17
9	13	19	11	29	10
10	E*c* 24	20		30	11

Mean; 29 days=19.2.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group or spot through the central meridian.
c=New formation of a center of activity: E, on the eastern part of the sun's disk; M in the central zone.
d=Entrance of a center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[The Aerological Division, W. R. GREGG, in charge]

By L. T. SAMUELS

Free-air temperatures were decidedly above normal at Chicago, Cleveland, Dallas, Ellendale, Omaha, and Washington, with the greatest departures therefrom occurring at Omaha at 2,000 and 2,500 meters. At Due West the departures were small and negative at the higher levels. Normal temperatures for Hampton Roads, Pensacola, and San Diego are not available.

In connection with the large positive temperature departures at Omaha it will be noted from Table 2 that the resultant wind movement for the month based on 7 a. m. observations contained a large southerly component as compared with the resultants at Chicago and Cleveland, in practically the same latitude.

The relative humidity departures from the normal were mostly negative at the lower levels and positive at the higher levels.

The free-air resultant wind directions for the month at the 1,000-meter level were close to normal, while the resultant velocities were considerably in excess of the normal at most stations. At 3,000 meters the resultant directions were close to normal at the northern stations but differed appreciably at a number of southern and west coast stations. In most cases where the monthly resultant direction varied from the normal the resultant velocity was below normal.

From Table 3 it will be noted that airplane observations were obtained at all four stations on every day during the month. The maximum altitude reached was 7,018 meters above sea level at Omaha on the 13th.

TABLE 1.—*Mean free-air temperatures and humidities obtained by airplanes (or kites) during September, 1931*

TEMPERATURE (°C.)

Altitude (meters) m. s. l.	Chicago, Ill.[1] (190 meters)	Cleveland, Ohio[2] (245 meters)	Dallas, Tex.[1] (149 meters)	Due West, S. C.[2] (217 meters)	Ellendale, N. Dak.[2] (444 meters)	Hampton Roads, Va.[3] (2 meters)	Omaha, Nebr.[1] (299 meters)	Pensacola, Fla.[3] (2 meters)	San Diego, Calif.[3] (9 meters)	Washington, D. C.[3] (2 meters)
Surface	17.3	17.1	23.3	23.4	18.0	24.1	18.4	24.6	21.4	21.0
500	18.2	18.4	24.1	21.5	17.9	22.3	19.1	23.7	17.8	21.2
1,000	17.9	17.5	23.4	18.7	16.9	19.9	20.8	21.2	19.0	19.7
1,500	16.1	15.1	21.2	15.7	14.7		19.6			
2,000	13.8	12.5	18.3	13.0	12.2	14.4	17.0	15.5	15.8	14.5
2,500	10.9	10.0	15.5	10.1	9.5		13.9			
3,000	8.1	7.6	12.7	7.4	6.3	8.1	10.5	9.7	9.8	9.0
4,000	1.9	2.4	5.9	0.8	−0.3		3.7	1.7		2.9
5,000	−4.3	−2.8	0.3	−5.4	−6.9		−3.1			
6,000		−7.2	−3.9		−12.6		−9.9			
7,000							−18.4			

RELATIVE HUMIDITY (PER CENT)

Altitude (meters) m. s. l.	Chicago	Cleveland	Dallas	Due West	Ellendale	Hampton Roads	Omaha	Pensacola	San Diego	Washington
Surface	85	84	71	73	61	72	78	86	69	78
500	74	74	66	70	60	67	72	76	76	65
1,000	64	67	59	68	52	66	57	72	50	59
1,500	58	63	59	66	51		53			
2,000	55	59	58	62	52	58	53	64	28	56
2,500	56	54	55	57	52		53			
3,000	54	48	54	53	54	46	55	56	21	53
4,000	53	44	54	55	58		53	52		54
5,000	47	45	42	66	59		50			
6,000		95	75		57		47			
7,000							74			

[1] Airplanes (Weather Bureau). [2] Kites. [3] Airplanes (Navy).

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 7 a. m. (E. S. T.) during September, 1931*

Altitude (meters) m. s. l.	Albuquerque, N. Mex. (1,528 meters) Direction	Velocity	Brownsville, Tex. (12 meters) Direction	Velocity	Burlington, Vt. (132 meters) Direction	Velocity	Cheyenne, Wyo. (1,873 meters) Direction	Velocity	Chicago, Ill. (198 meters) Direction	Velocity	Cleveland, Ohio (245 meters) Direction	Velocity	Dallas, Tex. (154 meters) Direction	Velocity	Due West, S. C. (217 meters) Direction	Velocity	Ellendale, N. Dak. (444 meters) Direction	Velocity	Havre, Mont. (762 meters) Direction	Velocity	Jacksonville, Fla. (14 meters) Direction	Velocity	Key West, Fla. (11 meters) Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	N 28 E	0.5	S 66 E	0.9	S 2 W	1.9	N 86 W	3.5	S 17 W	1.5	S 13 W	1.6	S 27 E	2.0	N 41 E	0.7	N 81 W	1.0	S 84 W	0.9	N 17 W	1.3	S 79 E	2.1
500			S 46 E	6.2	S 62 W	3.4			S 50 W	6.5	S 62 W	5.6	S 17 W	8.5	N 15 W	1.1	S 85 W	0.9			N 65 E	3.8	S 72 E	5.4
1,000			S 36 E	6.5	N 71 W	6.3			S 72 W	6.6	S 84 W	6.9	S 17 W	8.2	N 13 E	1.2	S 54 W	3.0	S 85 W	2.6	S 84 E	3.1	S 68 E	4.9
1,500			S 43 E	5.6	N 67 W	9.0			S 89 W	6.8	S 87 W	7.4	S 13 W	4.8	N 27 E	1.5	S 82 W	5.6	N 75 W	5.0	E	3.1	S 76 E	4.4
2,000	S 27 W	2.4	S 51 E	5.1	N 44 W	11.3	S 87 W	5.4	N 89 W	8.3	S 86 W	7.8	S 13 W	3.5	N 11 W	0.9	S 89 W	6.3	N 85 W	5.3	N 86 E	3.3	S 77 E	3.4
2,500	S 58 W	3.5	S 76 E	4.7	N 43 W	12.6	S 80 W	7.7	N 73 W	7.9	W	9.0	S 11 W	2.4	N 4 E	1.2	S 87 W	8.2	S 83 W	6.2	N 79 E	4.1	S 83 E	3.9
3,000	S 58 W	5.3	S 82 E	5.4	N 52 W	11.6	S 84 W	8.0	N 69 W	8.1	N 80 W	9.8	S 30 E	1.0	N 13 W	2.1	S 81 W	9.8	S 70 W	6.9	N 77 E	3.6	S 89 E	4.2
4,000	S 63 W	6.3	N 45 E	6.5			S 86 W	7.6	N 64 W	8.6	N 78 W	9.3	N 9 E	1.8	N 37 W	2.9	N 86 W	11.1			N 57 E	3.9	N 80 E	4.3
5,000	S 59 W	5.9					S 82 W	7.6			S 85 W	8.1			N 40 W	3.5	N 87 W	10.3			N 31 E	2.1	N 60 E	3.3

Altitude (meters) m. s. l.	Los Angeles, Calif. (127 meters) Direction	Velocity	Medford, Oreg. (410 meters) Direction	Velocity	Memphis, Tenn. (145 meters) Direction	Velocity	New Orleans, La. (25 meters) Direction	Velocity	Oakland, Calif. (8 meters) Direction	Velocity	Oklahoma City, Okla. (392 meters) Direction	Velocity	Omaha, Nebr. (299 meters) Direction	Velocity	Phoenix, Ariz. (356 meters) Direction	Velocity	Salt Lake City, Utah (1,294 meters) Direction	Velocity	Sault Ste. Marie, Mich. (198 meters) Direction	Velocity	Seattle, Wash. (14 meters) Direction	Velocity	Washington, D. C. (10 meters) Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	N 23 E	0.7	S 31 W	0.1	S 5 W	1.3	N 42 E	1.0	S 45 E	0.2	S	3.5	S 37 E	1.7	S 85 E	1.6	S 28 E	3.5	N 33 E	0.3	S 31 E	1.5	N 50 W	0.5
500	S 89 E	0.8	S 61 W	0.3	S 47 W	4.9	N 89 E	2.4	N 39 W	2.5	S 12 W	7.9	S 1 W	4.5	S 69 E	1.7			N 86 W	2.5	S 45 W	2.7	N 58 W	2.9
1,000	S 76 E	0.7	N 79 W	0.8	S 50 W	4.5	S 57 E	2.5	N 1 E	3.6	S 31 W	13.9	S 40 W	11.6	S 15 E	0.5			N 76 W	6.2	S 40 W	2.6	N 53 W	4.3
1,500	S 50 W	1.1	S 24 E	0.6	S 49 W	4.3	S 49 E	2.9	N 5 W	1.8	S 46 W	9.4	S 49 W	10.4	S 26 W	2.1	S 12 E	5.5	N 76 W	6.9	S 66 W	1.5	N 62 W	5.8
2,000	S 24 W	2.9	S 37 W	0.6	S 38 W	3.0	S 62 E	2.9	N 12 W	3.1	S 43 W	6.2	S 53 W	9.1	S 14 W	3.6	S 13 W	5.0	N 70 W	7.3	N 83 W	0.9	N 67 W	6.9
2,500	S 39 W	4.3	S 71 W	2.4	S 31 W	4.2	S 71 E	2.5	N 15 W	4.4	S 46 W	3.8	S 70 W	6.2	S 20 W	5.8	S 35 W	4.3	N 74 W	9.2	N 6 E	2.7	N 68 W	6.1
3,000	S 33 W	5.1	N 86 W	3.2	S 27 E	1.4	N 83 E	1.0	N 14 W	4.7	N 32 W	1.3	S 48 W	5.7	S 26 W	6.6	S 50 W	5.4	N 68 W	10.7			N 75 W	6.3
4,000			N 44 W	3.3			N 42 E	2.0			N 3 W	1.6	S 59 W	2.8			S 68 W	7.6	N 72 W	10.7			N 89 W	4.8
5,000							N 82 E	1.5									S 88 W	4.5						

TABLE 3.—*Observations by means of airplanes, kites, captive and limited-height sounding balloons during September, 1931.*

	Dallas, Tex.[1]	Due West, S. C.	Ellendale, N. Dak.	Chicago, Ill.[1]	Cleveland, Ohio[1]	Omaha, Nebr.[1]
Mean altitudes (meters), m. s. l., reached during month	5,625	2,747	3,245	5,070	5,688	6,528
Maximum altitude (meters), m. s. l., reached	6,013	[2] 5,431	[2] 6,324	5,519	6,089	7,018
Number of flights made	30	30	31	30	30	30
Number of days on which flights were made	30	29	29	30	30	30

[1] Airplanes. [2] Limited-height sounding balloon flights.

WEATHER IN THE UNITED STATES

THE WEATHER ELEMENTS

[Climatological Division, OLIVER L. FASSIG, in Charge]

By M. C. BENNETT

GENERAL SUMMARY

September was abnormally warm—generally 4° to 10° above normal—east of the Rocky Mountains except in some extreme northeast and southern localities where the monthly averages were near the normal. West of the Rocky Mountains the temperatures were slightly above normal, except at a few stations in the Pacific coast districts which reported small deficiencies. Considering the entire country, it was the warmest September of record. Previous maxima for September were equaled or broken in many places from the northern Great Plains eastward, 104° being reported as far north as Minneapolis.

The monthly precipitation was very unequally distributed. More than normal was received north of the Ohio and lower Missouri Rivers, some sections receiving 100 per cent above normal for September. Large excesses above normal likewise occurred in portions of the Rocky Mountains area, the Pacific Northwest, and in southern Florida. Elsewhere there was a general deficiency. A large portion of the lower Mississippi Valley and much of the Southwest received less than 25 per cent of the normal, and the deficiencies were nearly as marked in the South Atlantic, western Great Plains, and central Pacific areas.

TEMPERATURE

The first week of September was warmer than normal in most portions of the country, particularly in the Plains States and the northern half of the Rocky Mountain region. Large portions of the Ohio Valley and the lower Lake region had practically normal temperatures this week. The fortnight from the 8th to the 21st was remarkably warm for September from the interior of the Middle Atlantic States westward and southwestward to the upper Mississippi Valley and the middle and southern Plains, and also moderately warmer than normal in New England, the South, the Dakotas, and most portions of the Rocky Mountain States, save Montana. In the far West this period was generally cooler than normal.

From the 22d temperatures generally were lower than they had been during the previous two weeks, the change progressing from the Northwest into the East and South, where some States had three or four days at the end of the month with temperatures lower than normal. The final 9-day period averaged cooler than normal in most north-central and northwestern areas, but warmer over much more than half the country; though the departure was generally small except from the lower Mississippi Valley westward to southern California, where it was usually +3° to +9°.

The month as a whole was probably the warmest September in the history of the weather service. From Colorado eastward to the Middle Atlantic States many States and numerous single stations report it the hottest September within the period available for computation, which is usually from 35 to 50 years. From South Dakota to Oklahoma the month averaged 7° to 9° hotter than normal, and practically everywhere else east of the Rocky Mountains from 3° to 6° hotter, save in much of Florida, New Hampshire and Maine where it was only about normal. Generally in Arizona, Utah, Idaho, Washington, and western Montana the month averaged a little warmer than normal, but in Nevada, southern Oregon, and northern and central California a little cooler.

The highest marks were 100° or above in most States, and in some eastern cotton States even 106° or 107°. Minnesota and several Plains States reported from 110° to 112°, but the very highest was 115° at Gila Bend, Ariz., on the 11th and again on the 28th. In the western half the highest readings occurred generally during the opening week, but in the eastern half either about the 11th or about the 18th. From Montana eastward to New England several stations noted marks higher than any of previous September record.

The lowest readings in some Gulf States were above 40°, but in other States east of the Rocky Mountains between 40° and 25°. In the far West many high mountain stations reported lower temperatures, 8° being noted at a Wyoming station on the 23d. Lowest marks occurred largely about the 9th or about the 23d in the western half of the country, but in the eastern half usually during the final four days.

PRECIPITATION

The first week in September brought heavy rains to parts of the Florida Peninsula and to western Washington, most of the central valleys, the Ohio Valley, and large portions of New York and New England. The second week was mainly a period of little or no rainfall, though much of Florida and Michigan received considerable. The third week brought needed rains from northern Oklahoma and the eastern parts of Kansas and Nebraska northeastward to northern Michigan, also to northern New England and New York, and a large part of North Dakota.

The final 9-day period of the month was the time of best-distributed rainfall for the northern and central sections east of the Rocky Mountains, though there was heavy rainfall over most of Iowa and northern Missouri and the southwestern part of Wisconsin.

The distribution of the monthly precipitation was uneven and was notably scanty in nearly all of the South and a large part of the Plains. In Florida the situation was particularly diverse, Miami having the wettest September of record, while Jacksonville had the driest.

From South Carolina, Georgia, and northern Florida westward to include Arkansas and Louisiana there was very little rainfall and little also in southern and western Texas, and thence northward over the western Plains to the Black Hills area.

There was mainly much less rainfall than normal in southern Virginia and from New Jersey to Massachusetts.

More than normal rainfall occurred in the southern half of Florida, Miami measuring 19.70 inches. The Lake region received considerably more than normal and the Ohio Valley, somewhat more than normal, save the southwestern portion. Most of the upper Mississippi and lower Missouri Valleys had considerably more than normal, one Iowa station reporting 12.68 inches. From northern New Mexico to northwestern Montana the vicinity of the Continental Divide had usually more precipitation than normal, and the northern and western portions of Washington also had more than normal, one station in western Washington measuring 16.32 inches.

Several Western States report appreciable snowfall in their high mountain areas. Most of this snow occurred not long before the end of the month.

SUNSHINE AND RELATIVE HUMIDITY

More than the average amount of sunshine was received generally throughout the country during September, except in the far Northwest, much of the Lake region, northern New England, and southern Florida, where less than the usual amount prevailed. It was particularly large in the south-central Great Plains and eastward to the Atlantic. In the southern portion of the Florida Peninsula the daytime sky was only 27 per cent clear, while in some sections of the northern portion of that State it was 70 per cent clear.

The relative humidity was above normal in the Ohio Valley, the Lake region, the far Southwest and southern Florida. Elsewhere, it was generally below the average, with departures mostly small, except in the central Great Plains where they were rather pronounced.

SEVERE LOCAL STORMS, SEPTEMBER, 1931

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path (yards)	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Eureka, Mo., and vicinity	1	5:15 p. m.	100		$25,000	Tornado	Buildings and other property damaged; 5 persons injured; path 1 mile long.	Official, U. S. Weather Bureau.
Knoxville, Tenn	2	2:29 p. m.			2,000	Thunderstorm	Tower destroyed by lightning; power and telephone service impaired.	Do.
Reading and Berks County, Pa.	2	P. m.			25,000	Electrical and rain.	Barns and sheds burned; highways blocked by broken trees; heavy property damage at Mertztown	Do.
Lebanon, Ind. (6 miles southwest).	3				7,500	Electrical	Barn and contents burned	Do.
Shelbyville, Ind. (2 miles east).	3				20,000	do	A hangar, 4 planes, 3 trucks, and a tractor burned.	Do.
Muskingum and Noble Counties, Ohio.	4	P. m.			10,000	Hail	Considerable damage to crops and buildings	Do.
Grand Rapids (near), Mich.	4				25,000	Electrical	Amusement park and church damaged by lightning.	Do.
Port Arthur, Tex	5					Wind and rain squal.	Trees uprooted; tanker broke away from dock causing some damage.	Do.
Atoka, Okla	6	5 p. m.	440	1		Wind	Ball park grandstand demolished; roofs torn off; windows broken; wires and trees blown down; path 2 miles long; 4 persons injured.	Do.
Palermo, Me	6	P. m.				Probably tornado.	Buildings demolished or moved; several persons hurt.	Washington (D. C.) Post.
La Porte, Tex	10	3 p. m.				do	Timber and awnings damaged in bay-shore area.	Official, U. S. Weather Bureau.
Cascade and Teton Counties, Mont.	10					Hail	Chief damage to crops	Do.
Dane, Jefferson, Waukesha, Milwaukee, Ozaukee, Door, Brown, and Calumet Counties, Wis.	12	2:30 - 5:30 p. m.			217,000	Wind and thunderstorms.	Wires, poles, trees, and signs blown down; windows broken; barns wrecked.	Do.
Adrian, Mich	12					Rain, hail, and wind.	Light poles, trees, and other property considerably damaged.	Do.
Glacier County, Mont	12					Hail	Crops damaged	Do.
Fayette and Ross Counties, Ohio.	14-17			1		Wind, electrical and rain.	Much damage to property by flooding; several injured and 45 stunned by lightning.	Do.
Canton, N. Y. (vicinity of).	15				10,000	Electrical	Large barn and other buildings burned or damaged.	Do.
Thornburg, Kans. (3 miles southeast).	18	6:30 p. m.				Tornado	Number of farm buildings wrecked; path 4 miles long.	Do.
Knoxville (near), Tenn	19	2:50 p. m.			8,000	Thunderstorm	Barn and contents burned; farm machinery damaged.	Do.
Hanlontown (near), Iowa	19	7:30 p. m.			3,200	Tornado	Buildings damaged; livestock killed; path 5 miles long.	Do.
Clay and Palo Alto Counties, Iowa.	19	P. m.			12,000	Wind and rain	Trees, small buildings, windmills and electric wires damaged; some small buildings wrecked.	Do.
Crawford and Humboldt Counties, Iowa.	19					Wind	Roofs and chimneys damaged; corn blown down.	Do.
Linn and Sioux Counties, Iowa.	19					Rain and flood	Sewers flooded; railroad washed out; train derailed.	Do.
Buena Vista County, Iowa.	20	4-4:10 p.m.	1,760		5,000	Hail	Windows and auto tops pierced; corn injured	Do.
Slaton (near), Tex	20	8:15 p. m.	3,520		30,000	Wind	Chief damage to buildings; some crop injury; path 20 miles long.	Do.
Cass and Monona Counties, Iowa.	20				12,000	Wind and hail	Auto tops, roofs and windows pierced; corn injured; electric wires damaged.	Do.
Grantsburg, Wis	20					Hail	Crops and trees considerably damaged	Do.
Tama County, Iowa	20					Wind	Awnings and store fronts damaged; small buildings demolished; 20 electric poles blown down.	Do.
Davis County, Iowa	21	3:15-3:30 p. m.	100		400,000	Tornado, wind and hail.	Trees mutilated; houses, barns and windmills wrecked; 600 homes unroofed; overhead wires damaged; 20 persons injured; path 11 miles long.	Do.
Van Buren, Jefferson, Henry, Washington, and Louisa Counties, Iowa.	21	3:30-4:30 p. m.	33-100	2	125,000	Tornado	Damage confined to rural districts; overhead wires damaged; livestock killed; 8 persons injured; path 50 miles long.	Do.
Labette, Cherokee and Crawford Counties, Kans.	21	4:10-4:30 p. m.	880	2	50,000	do	Practically every building at Oswego fair grounds damaged; heavy property damage elsewhere; path 35 miles long.	Do.
Lamar (near), Mo	21	5 p. m.	1,760		2,000	Small tornado	Barn, silo and some small sheds blown down	Do.
Poweshiek County, Iowa	21	do			8,000	Wind	Farm buildings and trees damaged; airplane wrecked.	Do.
Scott County, Iowa	21	5:30 p. m.			5,000	Hail and wind	Roofs and windows pierced; corn stripped	Do.
Arnett, Okla. (2 miles northwest).	21	7 p. m.	200		1,200	Wind	Damage to property other than crops; path 4 miles long.	Do.
Columbia, Mo. (southern part).	21	do	2 blocks		20,000	Small tornado	City and university buildings damaged; 1 person injured.	Do.
Oxfordville (near) to Oconomowoc, Wis.	21	7:30-9 p. m.	200	1	300,000	Possibly 2 tornadoes.	Many farm buildings wrecked; crops ruined; over 40 families reported homeless or in need of aid; 9 persons injured; path 50 miles long.	Do.
Pittsfield, Ill	21				10,000	Wind	Poles and trees blown down; roofs damaged; wire service temporarily cut off.	Do.
Overbrook, Kans., and vicinity.	22	4:10 p. m.	1,760		3,000	Tornadic wind	Farm buildings, growing crops and telephone wires damaged; path 2.5 miles long.	Do.
Butler County, Iowa	23	4:30 p. m.			4,000	Wind	Several small buildings and roofs damaged; trees uprooted; auto tops torn; 2 persons injured.	Do.

Severe local storms, September, 1931—Continued

Place	Date	Time	Width of path (yards)	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
New Mexico (northern Rio Grande area).	23-24					Floods	Highways, railway, fields and crops damaged; homes flooded.	Official, U. S. Weather Bureau.
Norway (near), Kans	24	7:30 p. m.	880		5,000	Tornado and hail	Livestock killed; crops injured; 10 persons hurt; path 8 miles long.	Do.
Rush County, Ind. (central).	25	2 p. m.	440-880			Thunderstorm and wind.	Considerable damage to buildings; telephone service interrupted.	Do.
Boston, Ind	25	2:45 p. m.	100-130		100,000	Tornado	2 school buildings and a number of dwellings damaged; crops hurt; 25 persons injured.	Do.
Grayville (near), Ill	25				4,500	Wind	Buildings damaged	Do.
Anderson, S. C	26	A. m.			10,000	Thunderstorm	Several barns and contents destroyed by lightning.	Do.

RIVERS AND FLOODS

By MONTROSE W. HAYES

[In charge River and Flood Division]

Local overflows in small streams occurred in September in northwestern New York, Ohio, Michigan, Wisconsin, and New Mexico. The resulting damage was of minor consequence. A few rivers rose to stages slightly above bankful, as shown in the following table, but the only damage reported was in New Mexico, near Espanola, where there was estimated damage of $1,500 to highways, and $500 to crops:

Table of flood stages in September, 1931

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE					
	Feet			*Feet*	
Roanoke: Williamston, N. C	9	[1] 26	1	9.9	[1] 31
Peedee: Poston, S. C	18	[1] 29	1	18.9	[1] 31
MISSISSIPPI SYSTEM					
Missouri Basin					
Big Blue: Blue Rapids, Kans	20	25	26	20.8	25
Grand:					
Gallatin, Mo	20	26	26	23.3	26
Chillicothe, Mo	18	26	27	20.8	26
Ohio Basin					
White, West Fork: Edwardsport, Ind	10	17	18	12.0	18
WEST GULF OF MEXICO DRAINAGE					
Rio Grande: Espanola, N. Mex	7	24	24	8.1	24

[1] In August.

All dates are in September, unless otherwise indicated.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

[By the Marine Division, W. F. MCDONALD in charge]

PRELIMINARY NOTE

The most important feature of the weather of the month from the marine standpoint was the occurrence of an unusual number of tropical disturbances, seven in American waters and at least four in Asiatic waters. The American group affected the Caribbean area, the Yucatan Peninsula, Mexico, and the Pacific coastal waters adjacent to Mexico, with one hurricane producing a major disaster at Belize, British Honduras, on September 10. Special articles appear elsewhere in this issue covering the American disturbances and the first of the typhoons. The discussion has therefore been limited to brief mention in those cases below.

NORTH ATLANTIC OCEAN

By W. F. MCDONALD

The pressure situation.—Average pressures for the month of September were much above normal in the region of the northeastern Atlantic, with the Shetland Islands apparently at the center of the pressure anomaly. On the other hand, the barometer averaged lower than normal over much of the western Atlantic, centering about Newfoundland and Nova Scotia, with the Gulf and West Indies showing a slight excess of pressure north of the twentieth parallel of latitude and a slight deficiency in the Caribbean Sea and Central America.

In so far as the averages for the month may be said to have significance, they represent a displacement of the normal North Atlantic HIGH northeastward, with a corresponding displacement of the LOW center of action to westward, so that the latter (resulting in fact from the combination of several separate movements of centers of low barometric pressure) obtained sway over the region of the northwestern Atlantic, Greenland, and Labrador. The mid-Atlantic HIGH was seldom well developed in the region between the Azores and Bermuda, the crest of this ridge probably being displaced southward during much of the month.

Early in the month, the movement of LOWS into the Atlantic was on an unusual track, almost due eastward along the latitude of 40°, the disturbances being as a rule but weakly developed, but nevertheless persistent in their progress eastward over the area normally occupied by well-developed HIGH formations. After the 6th a persistent HIGH was set up over the British Isles that lasted almost continuously until the 30th.

Beginning about the 10th, the LOWS over the northwestern Atlantic and adjacent land areas became more intense and in general moved slowly northeastward, crossing Greenland and passing mostly to the northward of Iceland. These developments culminated in an exceptionally deep cyclonic depression, season considered, which was central over the Strait of Belle Isle on the 25th, with minimum pressure below 29 inches.

Charts VIII to XI, in this issue, cover four of the daily pressure situations over the Atlantic in September, the first three giving the general setting for hurricane movements, and the last showing the conditions attending the stormiest day of the month, in point of number of gales reported, on the main northern trans-Atlantic steamer routes. Table 1 gives some details of the monthly barometric pressures.

Gales and tropical disturbances.—Three tropical storm movements crossed the Caribbean area in the month, these being discussed at length in a separate article in this number of the REVIEW. It is worthy of note here, however, that no ship reporting to this bureau encountered winds of hurricane force in connection with these storms in the open sea on the Atlantic side of the continent, the hurricane damages being inflicted on the coasts as the storms passed.

Most of the gale reports on the main trans-Atlantic steamer routes appear on the 23d to 25th, at which time winds of force 8 to 9 were encountered quite generally over the area between 30° and 60° W. longitude and north of 45° latitude.

Fog.—Fog continued to decrease over the North Atlantic, being confined mostly to the vicinity of the Grand Banks where it was reported in places on about 25 per cent of the days of the month, with some fog off the entrance to New York Harbor on the 5th, 12th, and 13th. A brief spell of rather extensive fogginess, on the 17th and 18th, was encountered between mid-Atlantic and the British Isles.

Trans-Atlantic aviation.—The only attempt at a crossing of the Atlantic by airplane during September was the Rody-Johanssen-Viega flight westward from Portugal, beginning on the morning of the 13th. The plane was sighted over the Azores on its way out into midocean on a course toward Nova Scotia, and after 33 hours was sighted again, about 400 miles east of Halifax, by the steamship *Pennland*. The flyers were forced down, however, without making land, and were rescued only after floating at sea for a week, being picked up by the Norwegian motor ship *Belmoira* off Newfoundland on the 22d. The situation on the 14th, when the flyers were forced down, is depicted on Chart X.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, September, 1931*

Stations	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland [1]	29.89		30.36	1st	29.24	29th.
Reykjavik, Iceland [1]	29.95	+0.22	30.39	20th	29.24	29th.
Lerwick, Shetland Isles [1]	30.10	+0.26	30.57	21st	29.71	3d.
Valentia, Ireland [1]	30.22	+0.23	30.62	26th	29.44	3d.
Lisbon, Portugal [1]	30.05	+0.03	30.27	12th	29.87	23d.
Madeira [1]	30.04	+0.03	30.23	26th	29.84	23d.
Horta, Azores [1]	30.15	−0.02	30.39	11th	29.79	6th.
Belle Isle, Newfoundland [1]	29.80	−0.10	30.24	17th	28.96	26th.
Halifax, Nova Scotia [1]	29.91	−0.14	30.22	do	29.46	25th.
Nantucket [2]	29.98	−0.10	30.48	30th	29.52	24th.
Hatteras [2]	30.06	0	30.47	do	29.70	27th.
Bermuda [1]	30.07	−0.01	30.22	22d	29.86	29th.
Turks Island [1]	30.02	+0.04	30.08	26th	29.94	18th.
Key West [2]	29.95	+0.01	30.13	30th	29.80	9th.
New Orleans [2]	30.02	+0.04	30.23	do	29.84	8th.
Cape Gracias, Nicaragua [1]	29.84	−0.07	29.90	20th	29.74	19th.

[1] All data based on a. m. observations only, with departure computed from best available normals related to time of observation.
[2] Corrected 24-hour means, based on more than one observation daily.

OCEAN GALES AND STORMS, SEPTEMBER, 1931

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Inches*					
Jamaica Pioneer, Br. S.S.	Kingston, Jamaica.	Rotterdam	43 04 N	40 44 W	Sept. 2	2 p., 2	Sept. 4	29.92	ESE		ESE	ESE, 8	Steady.
City of Alton, Am. S. S.	Rotterdam	New York	50 12 N	6 30 W	Sept. 3	2 a., 4	do	29.38	NW	NW, 8	NW	NW, 8	Do.
Brave Coeur, Am. S. S.	New Orleans	London	49 25 N	16 30 W	do	6 a., 3	Sept. 3	29.65	N	NE, 9	N	NE, 9	N-NNE-N.
City of Alton, Am. S. S.	Rotterdam	New York	51 00 N	26 50 W	Sept. 7	8 a., 7	Sept. 7	29.68	SE	SE, 8	SE	SE, 8	Steady.
Illinois, Am. S. S.	San Pedro	Providence, R. I.	15 20 N	76 28 W	Sept. 8	9 a., 8	Sept. 8	29.53	NE	NE, 11	ESE	NE, 11	NE-E.
President McKinley, Am. S. S.	New York	Cristobal	16 07 N	81 45 W	Sept. 9	1:30 p., 9	Sept. 9	29.38	E	SSE, 10	S	E, 11	E-SE.
Atenas, Am. S. S.	New Orleans	Port Limon and return.	16 39 N	83 00 W	do	5 p., 9	do	29.49	E	E, 9	SE	SE. 9	E-SE.
Heredia, Am. S. S.	do	Puerto Barrios, etc.	16 49 N	87 00 W	Sept. 10	11:30 a., 10	Sept. 10	29.60	WSW	S, 10	SE	—, 10	WSW-SE-S.
Gatun, Hond. S. S.	do	Ceiba, Honduras, and return.	18 19 N	86 42 W	do	1 p., 10	do	29.74	E	ESE, 9	SE	ESE, 9	E-S-ESE-SE.
Milwaukee, Germ. M. S.	Cobh	New York	47 10 N	39 20 W	Sept. 11	9:24, 11	Sept. 11	29.75	SSE	S, 8	SSW	S, 8	SE-S-SW.
Do	do	do	46 00 N	42 58 W	Sept. 12	9:12, 12	Sept. 12	29.40	SW	S, 8	W	S, 8	SW-S-W.
Ambridge, Am. S. S.	Rotterdam	do	50 20 N	30 47 W	do	4 p., 15	Sept. 16	29.91	W	SSW, 7	WSW	S, 8	WSW-SSW-SW.
Amapala, Hond. S. S.	Ceiba	do	19 20 N	85 50 W	Sept. 14	1 a., 14	Sept. 14	29.85	NNE	NE, —	ESE	—, 8	NNE-ESE.
Wytheville, Am. S. S.	Rotterdam	do	49 00 N	40 52 W	Sept. 22	5:20 a., 23	Sept. 24	28.87	E	NNW, 9	W-N	NW, 9	E-SE-NW.
Collamer, Am. S. S.	Bordeaux	do	48 25 N	39 15 W	Sept. 23	4 p., 23	do	29.11	SSW	WNW, 8	W	WNW, 9	SW-W-WNW.
Europa, Germ. S. S.	Cherbourg	do	48 49 N	27 22 W	do	6:00, 24	do	29.61	S	SSE, 9	W	SE, 9	6 points.
Belgenland, Br. S. S.	New York	Plymouth	47 47 N	31 22 W	do	4 p., 23	do	29.37	S	SSE, 7	SSE	SSE, 9	Steady.
Cameronia, Br. S. S.	Glasgow	New York	50 20 N	43 40 W	do	9 a., 23	do	29.17	ENE	NNW, 9	W	NNW, 9	NE-N-NNW.
Tiger, Norw. Tk. S. S.	Baton Rouge	Bergen	52 59 N	41 12 W	do	9:30 a., 24	do	28.65	N	WNW, 3	WNW	NNW, 9	N-WNW.
Ala, Am. S. S.	Antwerp	Baltimore	50 39 N	26 24 W	do	6 a., 24	Sept. 23	29.64	SE	SE, 8	S	SE, 9	SE-S-SSW.
Tiger, Norw. Tk. S. S.	Baton Rouge	Bergen	53 26 N	39 45 W	Sept. 24	5 p., 24	Sept. 25	28.94	SW	SW, 4	SW	SW, 8	
Cameronia, Br. S. S.	Glasgow	New York	44 40 N	56 37 W	do	6:15 a., 25	Sept. 26	29.13	SSE	SSE, 7	W	WSW, 9	SSE-W.
Ala, Am. S. S.	Antwerp	Baltimore	49 44 N	38 00 W	Sept. 25	10:30 a., 26	Sept. 27	29.74	S	WSW, 7	W	SW, 9	S-SW-S.
Collamer, Am. S. S.	Bordeaux	New York	47 02 N	50 05 W	do	3 a., 26	Sept. 26	29.48	SW	WSW, 8	W	W, 9	WSW-W.
City of Alton, Am. S. S.	New York	Rotterdam	42 48 N	59 30 W	do	—, 25	do	29.43	WNW	WNW, 7	W	W, 8	Steady.
Oina, Br. Tk. S. S.	Port Arthur	Montreal	48 50 N	63 54 W	do	—, 25	Sept. 25	29.14	NW	WNW, 10	NW	NW, 10	Do.
Cold Harbor, Am. S. S.	Boston	Manchester, England.	49 12 N	43 48 W	Sept. 26	9 a., 26	Sept. 27	29.64	S	SW, 8	WSW	SW, —	S-SW.
George H. Jones, Am. S. S.	Las Piedras	New York	14 49 N	71 50 W	Sept. 7	11 p., 7	Sept. 8	29.60	S	S, 8	SE	S, 8	WSW-S.
Calamares, Am. S. S.	Habana	Cristobal	17 08 N	82 04 W	Sept. 9	5 p., 9	Sept. 9	29.67	E	E, 7	SSE	SE, 8	E-SE.
Alegria, Hond. S. S.	Philadelphia	Port Antonio, Jamaica.	18 12 N	77 02 W	Sept. 12	2 p., 12	Sept. 12	29.72	NE	SSE, 11	SSW	SSE, 11	NE-SE.
Cartago, Am. S. S.	New Orleans	Puerto Barrios	19 25 N	85 50 W	Sept. 13	4 a., 14	Sept. 14	29.68	ENE	ENE, 7	SE	SE, 7	ENE-SE.

Ocean gales and storms, September, 1931—Continued

Vessel	Voyage: From—	Voyage: To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
NORTH PACIFIC OCEAN			° ′	° ′				Inches					
Victoria, Am. S. S.	Seattle	Nome	50 50 N	134 05 W	Sept. 4	Noon, 4	Sept. 5	29.34	SE	SSW	W	SSW, 9	SW-W.
Siamese Prince, Br. M. S.	Los Angeles	Shanghai	34 44 N	172 20 E	do	7 a., 5	do	[1]29.89	SW	SSW, 8	NW	NW, 8	SW-W-NW.
Do	do	do	34 54 N	153 56 E	Sept. 7	11 p., 7	Sept. 8	[1]30.00	SW	do	NW	SSW, 8	WSW-NW.
Chief Capilano, Br. S. S.	Taketoyo	Vancouver	34 41 N	139 42 E	Sept. 9	Noon, 10	Sept. 11	29.65	NE	N, 7	NNW	N, 8	N-NNW.
San Luis Maru, Jap. M. S.	Elwood	Yokohama	34 00 N	155 50 E	Sept. 11	2 a., 13	Sept. 13	[1]29.42	SSW	ESE, 6	N	SE, 8	SE-ESE-E.
Courageous, Am. M. S.	Shanghai	San Pedro	39 34 N	138 44 E	Sept. 12	2 p., 12	Sept. 12	29.16	SE	SE, 12	SE	SSE, 12	SE-SW.
Kurohime Maru, Jap. S. S.	Osaka	Portland	48 51 N	178 28 E	Sept. 18	1 p., 18	Sept. 18	29.38	WSW	W, 8	W	W, 8	WSW-W.
Do	do	do	49 20 N	166 16 W	Sept. 19	11 a., 20	Sept. 20	28.40	N	NNW, 12	WSW	NNW, 12	N-NW.
Olympia, Am. S. S.	Cebu, P. I.	Los Angeles	40 16 N	168 30 W	do	3 p., 19	do	[1]29.12	NE	N, 9	W	WNW, 12	NNW-WNW.
Courageous, Am. M. S.	Shanghai	San Pedro	47 30 N	158 25 W	do	10 a., 20	do	29.36	NE	SSW, 10	SW	SSW, 10	SSW-S.
Kiyo Maru, Jap. S. S.	Sado Is.	Los Angeles	46 05 N	154 30 W	do	4 a., 20	do	29.74	SSE	SE, 7	SW	SSE, 9	SSE-S.
Somedono Maru, Jap. S. S.	Miike	Port Angeles	49 32 N	171 00 W	Sept. 20	2 p., 20	do	29.54	N	NW, 8	NW	NW, 8	N-NW.
City of Vancouver, Can. S. S.	Osaka	Prince Rupert.	44 59 N	162 40 E	Sept. 21	8 p., 22	Sept. 23	29.65	W	W., 7	WNW	W, 8	Steady.
Granville, Pan. M. S.	Hong Kong	San Pedro	22 25 N	121 55 E	Sept. 23	4 a., 24	Sept. 24	29.62	SW	SSE, 8	S	S, 9	SW-S.
Asuka Maru, Jap. M. S.	Yokohama	San Francisco	36 36 N	143 54 E	Sept. 26	6 p., 27	Sept. 28	[1]29.64	SE	SE, 9	SSE	SE, 9	
Shoyo Maru, Jap. S. S.	do	do	47 45 N	163 30 W	Sept. 27	8 p., 28	Sept. 30	[1]29.41	SW	W	WNW	NW, 9	W-NW.
Hakubasan Maru, Jap. M. S.	do	do	48 02 N	164 24 W	do	do	do	29.54	S	WNW		NW, 9	
Victoria, Am. S. S.	Nome	Seattle	53 50 N	149 05 W	Sept. 29	4 a., 29	do	28.66	N	WNW	WSW	WSW, 9	
Yukon, Am. S. S.	Seattle	Seward	58 26 N	138 00 W	Sept. 30	2 a., 30	do	28.74	NE	NE, 8	N	NE, 8	4 points.
MEXICAN WEST COAST STORM REPORTS													
Marian Otis Chandler, Am. S. S.	Los Angeles	Philadelphia	16 00 N	98 00 W	Sept. 6	8 p., 6	Sept. 7	29.67	Var	E, 3	ENE	ENE, 8	E-Var.
Sea Thrush, Am. S. S.	Balboa	San Pedro	20 48 N	108 12 W	Sept. 9	—, 11	Sept. 12	29.45	SE	NE, 8	WSW	NE, 10	ENE-NE.
City of Elwood, Am. M. S.	do	do	21 00 N	107 52 W	Sept. 10	do	do	29.60	ESE	S, 8	SW	SSE, 8	S-SSE.
Astronomer, Br. S. S.	Los Angeles	Balboa	20 35 N	107 26 W	Sept. 11	5 a., 11	do	28.73	SE	SE	SSW	SxW, 10	SE-S-SSW.
San Raphael, Am. S. S.	Philadelphia	San Pedro	22 00 N	108 58 W	do	4 a., 12	do	29.53	SE	SW, 9	S	SW, 9	SSW-SW.
Chattanooga City, Am. S. S.	Balboa	do	20 27 N	107 35 W	do	—, 12	do	29.63	SE	SE, 7	SSW	SSE, 8	SE-SW.
W. S. Miller, Am. S. S.	Mazatlan	Cape San Lucas.	23 00 N	107 00 W[2]	do	9 p., 11	do	29.40	SSE	SE, 12	SW	SE, 12	Steady.
Malayan Prince, Br. S. S.	Colon	Los Angeles	15 30 N	101 30 W[2]	Sept. 13	4 p., 14	Sept. 14	29.58	WSW	WSW, 9	W	WSW, 9	
San Felipe, Am. S. S.	San Pedro	Balboa	17 45 N	103 25 W	Sept. 14	do	do	29.54	SE	E, 4	SW	E, 8	SE-E.
Willboro, Am. S. S.	Balboa	San Diego	18 11 N	104 01 W	Sept. 15	6 a., 15	Sept. 15	29.60	SE	SE, 7	SE	SE, 10	Steady.
Piave, It. S. S.	Colon	Los Angeles	20 00 N	106 00 W	Sept. 17	3 a., 17	Sept. 19		NW	NW, 6	NNW	—, 8	
Seminole, Br. M. S.	Panama	San Pedro	17 43 N	103 19 W	Sept. 20	4 p., 20	Sept. 20	29.64	ESE	E, 7	E	E, 8	ESE-E.
American Star, Am. S. S.	San Francisco	Canal Zone	18 00 N	104 00 W[2]	do	do	do	29.61	ESE		ESE	ESE, 9	
Ohioan, Am. S. S.	Los Angeles	New York	18 48 N	104 17 W	Sept. 21	4 a., 21	do	29.69	E	ExS, 8	ExS	ExS, 8	Steady.
Suriname, Am. S. S.	San Francisco	Cristobal	19 40 N	105 45 W	do	10 p., 21	Sept. 22	29.67	NE	ESE, 8	SE	ESE, 9	E-ESE.
New Jersey, Am. S. S.	San Pedro	New York	21 31 N	108 26 W	Sept. 22	8 p., 22	do	29.49	E	E, 7	SSE	SE, 9	
Thos. H. Wheeler, Am. S. S.	Balboa	San Pedro	22 09 N	109 18 W	do	7 p., 22	Sept. 23	29.35	E	E, 8	SSE	E, 8	E-ESE.
Arizonan, Am. S. S.	San Francisco	New York	23 00 N	110 00 W[2]	do	4 a., 23	do	29.72	E	ESE, 8	S	SE, 9	E-ESE.
Dorothy Luckenbach, Am. S. S.	New York	San Pedro	21 46 N	108 59 W	do	4 p., 22	do	29.47	SE	SE, 9	N	SE, 9	Steady.
Robin Hood, Am. S. S.	Longview	Balboa	25 00 N	113 00 W[2]	Sept. 23	3 a., 24	Sept. 24	29.75	NE	SE, 7	SSE	E, 9	
Willkeno, Am. S. S.	Los Angeles	Charleston	18 42 N	105 06 W	Sept. 27	5 a., 27	Sept. 27	29.60	NNE	E, 9	SE	ESE, 10	ENE-E.
Vega, Am. S. S.	San Diego	Balboa	18 45 N	104 40 W	do	4 a., 27	do	29.68	E	E, 7	SE	ExS, 8	E-ESE.
Chas. R. McCormack, Am. S. S.	San Pedro	do	18 52 N	105 49 W	do	Noon, 27	Sept. 28	29.13	NNE	ESE, 12	SE	ESE, 12	E-ESE.
Minnesotan, Am. S. S.	Los Angeles	New York	20 15 N	108 47 W	do	6 p., 27	do	29.76	ESE	ESE, 7	SE	ESE, 8	ESE-SE.

[1] Barometer uncorrected.

[2] Position approximate.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

Atmospheric pressure.—With the coming of early autumn atmospheric pressure began to lessen over the upper waters of the North Pacific Ocean. Depressions became more frequent, and as they concentrated principally over the peninsula and neighboring Gulf of Alaska, it was here that the average center of the Aleutian LOW appeared during September. Pressures for the entire region, however, were above the normal for the month, as they were also in July and August.

The North Pacific anticyclone, while more restricted in area on the average than in August, remained for the most part well developed off the middle American coast and thence westward to about longitude 170° W. At Midway Island, however, as well as at coast stations of the United States, pressures were below normal.

Frequent cyclones and anticyclones appeared to the westward of longitude 160° E., but the average pressure was comparatively low in Asiatic waters south of the fortieth parallel, increasing thence northward for some distance.

The following table gives the barometric data for several island and coast stations in west longitudes, including Point Barrow on the Arctic Ocean:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean and adjacent waters, September, 1931, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow [1]	29.96	+0.06	30.34	13th	29.64	30th.
Dutch Harbor [1]	29.89	+0.13	30.44	26th	29.10	21st.
St. Paul [1] [2]	29.87	+0.16	30.42	26th	29.36	16th.
Kodiak [1] [2]	29.77	+0.06	30.22	23d	29.18	29th.
Midway Island [1]	29.93	−0.08	30.12	30th	29.76	11th.[3]
Honolulu [4]	29.99	−0.01	30.16	27th	29.86	3d.
Juneau [4]	29.86	−0.06	30.60	21st	29.00	29th.
Tatoosh Island [4] [5]	29.98	−0.03	30.31	22d	29.57	18th.
San Francisco [4] [5]	29.93	−0.01	30.11	29th	29.67	22d.
San Diego [4] [5]	29.86	−0.03	29.99	3d	29.71	11th.

[1] P. m. observations in averages; a. m. and p. m. in extremes.
[2] For 29 days.
[3] And on other dates.
[4] A. m. and p. m. observations.
[5] Corrected to 24-hour mean.

Cyclones and gales.—During the early half of September comparatively quiet summer conditions prevailed along the upper trans-Pacific steamship routes, gales occurring only infrequently and over small areas. But from the 18th until the end of the month there was a sharp increase in the frequency and general severity of gales and an expansion of the areas of storminess.

The principal extratropical cyclone of the month seems to have originated near and to the northward of Midway Island about the 18th. It was first known as a severe storm on the afternoon of the 19th when the American steamer *Olympia* encountered it in gales of strong to hurricane force near 40° N., 168° W. The cyclone by this time was moving rapidly northward. On the 20th at 11 a. m. local time, the Japanese steamship *Kurohime Maru* experienced it as a northerly to westerly gale of hurricane force, lowest barometer 28.40 inches, near 49° N., 166° W. Earlier in the day southwesterly gales of force 11 were reported by another vessel from about 42° N., 162° W. On this date of the storm's greatest severity and widespread prevalence gales equaling or exceeding force 9 covered a region bounded roughly by longitudes 150° and 170° W., latitudes 40° to 52° N. The cyclone center, losing energy, passed east of Dutch Harbor, where the barometer fell to 29.10 inches on the morning of the 21st and by the 22d had entered the Arctic Ocean north of Alaska.

An eastward-moving LOW of less intensity from Siberia entered the Sea of Okhotsk on the 20th. After leaving the Kuril Islands it caused fresh to strong gales to the eastward on the 20th to 22d. On the 23d it crossed the central Aleutians into the Bering Sea, and by the 25th had overspread the Gulf of Alaska, where it remained with fluctuating intensity until the close of the month. Some eastbound steamships on the northern routes between the 22d and 30th remained under the influence of this disturbance for several days harassed by frequent fresh to strong gales.

South of latitude 40° gales, so far as reported, were infrequent and of moderate to fresh force only, except those due to disturbances of the Tropics.

Tropical cyclones—Typhoons.—In addition to a very small but violent typhoon off the southeast China coast, a description of which by the Rev. Miguel Selga, director of the Philippine Weather Bureau, appears elsewhere in this issue of the MONTHLY WEATHER REVIEW, at least three other typhoons occurred in September, two of which our own reports show to have been of great violence. Two of these cyclones originated in low latitudes east of the Philippines. One, forming early in the month, moved northward between the Nansei Islands and the mainland of China on the 9th and 10th. By the 11th it had acquired considerable energy south of Chosen, and on the 12th in the Japan Sea the report of the American motor ship *Courageous* indicates that it was by then, at least, of hurricane intensity. The storm crossed the northern island (Yezo) of Japan and on the 13th lay over the Sea of Okhotsk.

The other low-latitude storm crossed the Philippines between the 19th and 21st, and Taiwan on the 22d and 23d. It skirted the west coast of the Japanese Archipelago between the 25th and 28th and went northward into Siberia west of Sakhalin Island.

The third typhoon was apparently the most severe. It first appeared as a LOW west of the Ogasowara Islands on the 7th. It proceeded northeastward and when central some 200 miles east-southeast of Yokohama, or near latitude 33° 39′ N., 142° 56′ E., at 4:30 p. m. of the 10th, according to the special report of the American steamship *Patrick Henry* (R. A. Smith, second officer and observer) was of hurricane force from southeast by south. The position of the vessel was practically stationary for several hours. Light winds occurred at the vessel from 9:30 to 10 p. m. The lowest barometer, 28.20 inches (uncorrected), was read at 10 p. m. "at the end of the southerly winds." The wind was of hurricane force from 4:30 p. m. until midnight, except for the comparative calm at the vortex, but was of greatest violence after the shift to west. The typhoon continued on a northeasterly course until the 12th, when it was lost to observation near 40° N., 160° E.

Mexican west coast cyclones.—At least three cyclones with winds of force 11 to 12 occurred in these waters in September; in addition to one other instance in which winds of whole gale force were encountered by several ships in positions strongly indicating a tropical storm development and movement. These storms are discussed in considerable detail in another section of this REVIEW, where they are considered chronologically with associated storms moving into Mexico from the Caribbean area. A brief summary of the movements in the Pacific which were all quite regularly northwestward, closely paralleling the Mexican west coast, is presented here as a part of the record of month's weather over the Pacific.

The first storm, which caused the loss of the American steamship *Colombia* on the 12th, and took a number of lives in the Mexican town of Santa Rosalia on the 13th, was first in evidence as a moderate cyclonic storm about latitude 15° N., longitude 100° W., on the 6th and 7th. It ceased to be a damaging storm after reaching the upper part of the Gulf of California on the 14th, on which date another disturbance was developing in approximately the same location where the first had originated a week before. This second storm was of only moderate violence, and, after following a course almost like its predecessor into the mouth of the Gulf of California, disappeared by the 18th. The third and fourth storms developed somewhat farther from the coast about 12° N., 102° W., the earlier on the 20th, and the last on the 26th. The movement of the first after the 20th was somewhat problematical, but it appears however to have traveled about due northwestward causing gales in the vicinity of

25° N., 115° W., on the 24th, after which it seems to have diminished and disappeared. The last storm, beginning on the 26th, moved more northward, and, like the first two of the month, entered the Gulf of California and disappeared after the 29th.

Winds at Honolulu.—The prevailing wind direction at Honolulu continued from the east, with the maximum velocity of 25 miles an hour from the east on the 25th.

Fog.—The occurrence of fog on the north Pacific lessened appreciably in September along the northern routes, and was reported on only 1 to 4 days in any 5° square. The region of most frequent occurrence lay along the American coast between 30° and 50° N., with about 30 per cent of the days with fog between Point Conception and the mouth of the Columbia River.

The Moyle-Allen airplane flight over the northwestern Pacific.—On September 8, Don Moyle and Cecil A. Allen, of California, took off from Sabishiro Beach, Japan, 375 miles north of Tokyo, attempting a nonstop flight of 4,465 miles to Seattle. They were thereafter lost until it was learned 10 days later that they had been forced down by stormy weather, landing upon a remote island of the western Aleutians. After seven days, they hopped off for Siberia, landing on the 17th on the Kamchatka coast, 1,900 miles north-northeast of their starting point of the 8th. They later flew to Nome.

THE SILVERSANDAL TYPHOON, SEPTEMBER 1 TO 4, 1931

Abridged from a report submitted by Rev. MIGUEL SELGA, S. J., director of the Manila Weather Bureau

To pass from a gentle breeze into a whole gale in the short interval of two hours without any apparent sign of a brewing storm was the unusual experience on September 1, 1931, of the 3,693-ton motor ship *Silversandal*, of the Silver Line. In its voyage from Shanghai to Manila the motor ship encountered gentle easterly breezes down the China coast and the Formosa Channel on the last day of August and the early morning of the 1st day of September, with the barometer remaining stationary at 755.8 mm. for eight hours. The usual precursors of a typhoon, such as convergence of cirri, shifts of the wind, or unusual swell, were all absent. No typhoon warning had been issued by the near-by broadcasting stations of Pratas and Keelung.

According to the log book, at 4 a. m. on September 1, when the *Silversandal* was approaching the northern entrance of the Formosa Channel, a gentle breeze was blowing from the northeast. The weather was noted down as fine and clear by the officer of the deck. At 8 a. m. the wind had increased one point in force and shifted to east by north, while short-lived rain squalls gave indications of unsettled weather. Two hours later the storm was on and the wind had increased to gale force. At 10:50 a. m. the wind was blowing whole gale and the speed of the ship had to be reduced. The barometer dropped to 744.5 mm. at 11:30, with the wind from east by north, of hurricane force. The blast of the whistle of the ship was lost in the roar of the wind and could not be heard by the members of the crew. The rain was blinding and the visibility so low that one end of the ship could not be seen from the other. At noon the wind was from the east and had dropped from force 12 to force 10, and by 4 p. m. the wind had veered to south-southeast and decreased to force 5 while the barometer had risen to 752.3 with general improvement of weather conditions.

This typhoon must have originated west of southern Formosa and passed north of Pratas in its westward motion without affecting considerably the barometers of western Formosa and of Pratas. No definite information on the origin and violence of the storm could be secured until the *Silversandal* made the port of Manila and the officers and log book of the ship were consulted.

The disturbance moved westward unnoticed throughout the evening and night of September 1, but at 6 a. m. on September 2, there were evident signs of a typhoon approaching Hong Kong from the southeast. About noon the gale developed with surprising suddenness in the British colony and many native craft were caught unawares.

Two unusual features characterized the passage of this typhoon close to Hong Kong—the unsteadiness of the winds and the oscillations of pressure. The wind vane of Hong Kong Observatory is reported as having made five complete revolutions between 8 and 11 p. m. In the words of the director of the royal observatory, the barometer trace was the most remarkable ever recorded at the observatory, the pen oscillating rapidly to the extent of a tenth of an inch between 8 and 9 p. m. Lowest pressure was 739.9 mm. at 2:55 p. m., attended by wind rising to a velocity of 124 kilometers per hour in the maximum gust, but some hours later the wind rose suddenly again to high velocities between 8 and 10 p. m., reaching a maximum velocity of 151 kilometers per hour in a gust at 9 p. m.

The mean speed of progression of the typhoon from the west of southern Formosa to the Asiatic Continent was about 8.6 miles per hour. The weather maps of September 4 show the center of the typhoon filling up over Kwangsi Province.

TROPICAL STORMS OF SEPTEMBER, 1931, IN NORTH AMERICAN WATERS

By W. F. McDONALD

September was marked in American tropical waters by no less than seven storms. At least three of these storms reached full hurricane intensity, one of them becoming a major disaster. Tracks of three storms which moved across the Caribbean Sea are illustrated elsewhere in this issue, in connection with a special report on hurricane damage in Porto Rico, the only United States possession to suffer by a hurricane during the month.

The first cyclonic development of the month began north of the Virgin Islands on the 1st, and was of minor intensity. It moved westward during the next six days reaching the western end of Cuba where it recurved northeastward on the 7th. The only gales reported during the progress of this relatively mild disturbance were over Mona Passage on the 2d, but flooding rains which caused great damage and some loss of life in Porto Rico may be attributed to conditions attending this cyclone.

While the first disturbance was in progress, another was developing in the southeastern Caribbean Sea. It was first suspected not far from Barbados on the 6th. The third for the month was also arising almost simultaneously in the Pacific a short distance southeastward from Acapulco, Mexico, where the American steamship *Marian Otis Chandler* encountered a cyclonic gale on the 6th. Both of these disturbances developed into storms of relatively small diameter but of full hurricane intensity as they progressed during the succeeding week.

While these two hurricanes were in simultaneous progress, and approaching the peak of their intensity, the

fourth tropical storm of the month was getting under way over the northern portion of the Leeward Islands on the 9th, and this storm likewise developed full hurricane intensity in its life of approximately a week as it moved westward to lose itself finally over the highlands of central Mexico.

It is of considerable interest, and perhaps of some importance for future studies of hurricanes, to point out that the three storms just mentioned, all of which reached the intensity of severe hurricanes, appear to have developed full severity at about the same time. The first storm ravaged Belize, British Honduras, on the afternoon of September 10, but ships encountering it earlier did not find winds of hurricane force. The second was first encountered as a hurricane of force 12 in the entrance to the Gulf of California on the 11th, and the third passed San Juan with damaging severity about midnight of the 10th–11th. The first two of these storms were in existence for four or five days however, before they reached hurricane intensity, but the third appears to have developed its strength within 36 hours from the time when its presence was first suspected, although it is possible that this storm may have originated still earlier in the little-traveled regions northeast of the Leeward Islands.

That three widely separated storm movements should thus show almost simultaneous increase in intensity may, of course, be pure coincidence, but it is not outside the bounds of probability that some major influence was at work in the weather conditions over the 2,000-mile arc embraced by the equally spaced locations of storms over Porto Rico, the Gulf of Honduras, and the entrance to the Gulf of California. The fact is at least worth recording for possible future reference.

The history of these three hurricanes will now be discussed in some detail, taking each in its chronological order by date of origin. As stated above, the Belize hurricane appears to have originated over the Windward Islands about the 6th of the month. The first ship's report, establishing conclusively its nature as a pronounced cyclonic depression, comes from the American tanker *Geo. H. Jones* (Captain Cavileer) near latitude 15° N., longitude 70° W., about midnight of the 7th–8th, with the barometer dropping sharply from 29.8 to 29.6, and a gale of force 8. The progress of this disturbance continued steadily west-northwestward during the next two days, with a number of ships reporting barometric decreases and winds at times reaching force 10 to 11, but none experiencing conditions of full hurricane intensity, even on the morning of the 10th in the Gulf of Honduras, where shipping is relatively numerous.

The 10th of September is a festival date in Belize, British Honduras, and the populace was out in holiday mood on the afternoon of that day as the hurricane, still of small extent but of ferocious intensity, moved in upon the town. It raged throughout much of the afternoon, reaching hurricane velocity about 1 p. m., and the center of the storm appears to have passed Belize about 3:30 p. m. Some details, excerpted from a report made by D. A. Fairweather, Government wireless operator at Belize, follow:

> The wind began to increase about 11 o'clock from the northeast and by 12:40 p. m. had reached a velocity of 48 miles an hour.
>
> At 1:15 p. m. the velocity was 60 miles and the barometer registered 28.10. Between 1:35 and 2:00 p. m. the wind lulled to 38–48 miles returning to 60 miles an hour at 2:05 p. m. from the north. It crept up to 72 miles an hour at 2:15 p. m., 96 miles at 2:30 p. m., 120 miles at 2:45 p. m. and maintained a velocity of 132 miles an hour from 2:50 to 3 p. m. At 3:05 p. m. the wind dropped to 72 miles and finally to about 12 miles.
>
> At 3:44 p. m. the wind shifted to the southwest and rose suddently to 80 miles an hour. The anemometer gave way at this juncture.

The winds swept the sea forward over the environs of the port, which is built on exceedingly low ground, choked the mouth of the Belize River with the wreckage of small boats, including six Honduran schooners, piled a 200-ton dredge upon the wharf, and with wreckage as battering rams, smashed into the structures of the town itself. It was a disaster of major proportions, entailing a loss of life that is not definitely known, but probably exceeding 1,500 souls, and a property loss that was estimated in later dispatches at $7,500,000.

Meanwhile, the third storm of the month was raging as a hurricane over the Gulf of California. As noted above, this storm probably began on the 6th, and was first reported by the American steamer *Marian Otis Chandler*, Captain Sawyer, which encountered a variable to east-northeast gale of force 8, with a lowest barometer of 29.67 inches, in latitude 16° N., longitude 98° W. If so, however, there is a gap in the storm history, owing to lack of reports, for it next appears on the afternoon of the 9th, when, at 8 p. m., the Dutch motorship *Drechdijk* encountered an east-southeast gale of force 8 near 19° 30′ N., 105° 35′ W., followed by conditions which indicated that the disturbance was passing to the northwestward.

A maximum wind of force 10, prior to the regular a. m. observation at the Mexican weather station at Manzanillo, with barometer reading 29.68 inches, marked the position of the disturbance to westward of that station on the morning of the 10th. On the morning of the 11th the British steamer *Astronomer* encountered the storm about 20° 30′ N. and 107° 30′ W. The further progress of the hurricane appears in the report of the American steamship *W. S. Miller*, which experienced a southeast hurricane near 23° N. and 108° W., and barometer down to 29.4 inches, at 9 p. m. of the same date. This was the first report to show that the storm had developed full hurricane intensity.

Late on the afternoon of the 11th the French steamer *Korrigan III*, lying in port at La Paz, Lower California, experienced the preliminary northeast gales of the approaching hurricane. The report of the first officer R. Moya of the *Korrigan III*, Capt. S. Meza, furnished to Mr. E. W. Easton, American vice consul at Mazatlan, Sinaloa, gives definite information as to the severity of the storm in this vicinity. By 2 a. m. of the 12th the wind in the harbor of La Paz was blowing with force 12 from the north, and the pressure was falling. At 3 a. m. the reading of the barometer on the *Korrigan III* reached 28.74 inches, followed for some minutes by greatly diminished wind. At 3:35 a. m. the wind came from the south and soon rose to force 10, as the hurricane center passed.

There was no great damage in La Paz as the hurricane passed, but with its further movement up the peninsula of Lower California, on the morning of September 12 it caused the American steamship *Colombia* to go aground on Santa Margarita Island as she became involved in the winds and possibly the unusual currents attending the hurricane's progress. This ship, a passenger liner en route from New York to San Francisco, carried 234 passengers and crew, all of whom were safely removed through able seamanship of the officers of the stranded vessel and the rescuing ship *San Mateo*, of the United Fruit Line. There was hope at first that the ship might be salvaged, but continued heavy weather prevented, and the vessel, abandoned on the 13th, broke up under stress of the seas developed during the following week by

the succeeding storm movement. More than $150,000 in gold and silver, carried by the *Colombia*, was later recovered, but the remainder of the cargo, including personal belongings of the passengers, seems to have been a total loss.

As the hurricane moved farther northward it was reported in press dispatches to have caused exceedingly high tides on the 13th at Guaymas and Santa Rosalia, Mexico, with approximately 50 lives lost by drowning in the 9-foot inundation of the latter town. From this point the storm seems to have diminished and dissipated, probably moving inland over the State of Sonora.

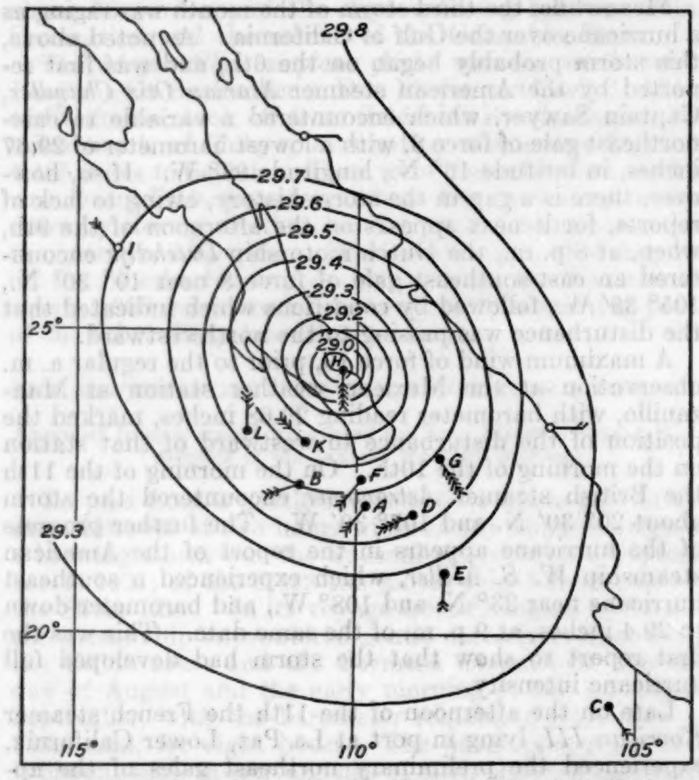


FIGURE 1.—Observations from vessels and near-by coast stations in the hurricane of Sept. 12, 1931, at Greenwich noon. Storm center just west of La Paz. Letters signify the following vessels: *A*, American steamer City of Elwood; *B*, American steamer Sea Thrush; *C*, British steamer Astronomer; *D*, American steamer San Raphael; *E*, American steamer Chattanooga City; *F*, American steamer Muntropic; *G*, American steamer W. S. Miller (position approximate); H, French steamer Korrigan III (4 a. m. in port at La Paz); *I*, American steamer President Van Buren; *K*, American steamer San Felice; *L*, American steamer Nebraska.

The wind and barometer conditions reported from several vessels caught in this storm on the early morning of September 12 (about Greenwich noon) are charted in Figure 1 to indicate the location and intensity of the hurricane at that time.

The fourth of the seven storms originating in September, first reported over the waters north of the Leeward Islands on the 9th, passed Porto Rico as a small but well-developed hurricane on the night of the 10th–11th. A report of its movement along the north coast of Porto Rico and of its characteristics at that time will be found elsewhere in this issue. The next definite report of its progress is from the Honduran steamship *Alegria*, which was in harbor at Port Antonio, Jamaica, on the 12th, and experienced typical hurricane conditions with wind shifting from northeast to southeast and of force 8 to 11 during that afternoon, but without extreme depression of the barometer.

Only one further gale report is at hand for this storm as it continued to travel due westward across the Caribbean Sea, namely that from the American steamship *Cartago* which reported a moderate gale, shifting from east-northeast to southeast, in 19° 25′ N., 85° 50′ W., early on the 14th. After this date the disturbance moved on across Yucatan and evidently into the lower Gulf of Campeche, finally passing inland over or near the city of Vera Cruz at 4 a. m. of September 16.

A special report received from Ing. Ernisto Dominguez, in charge of the meteorological observatory at Vera Cruz, gives the following facts: Preliminary evidences of the approach of the hurricane became unmistakable on the 15th, with a moderate northerly wind, increasing without a rise but rather a fall in the barometer. By afternoon the wind became gusty and was sufficiently strong by nightfall to make it necessary to close the port. By midnight the violence of the wind had risen to near hurricane force with the barometer dropping decidedly after 10 p. m., but the direction of the wind continued rather steadily from the north-northwest up to the time of barometric minimum, 29.43 inches, about 4 a. m., at which time there was a shift to east-northeast, indicating that the center of the disturbance moved inland to the south of the observatory.

The clouds were overrunning the surface wind, however, at 2 a. m., being from an easterly direction already at that hour. With the shift of the surface wind to easterly just before 4 a. m., there was an increase in force, and the maximum velocity was attained a little after 5 a. m., when 42.5 m. p. s. (95 m. p. h.) was recorded. The report states that this velocity established a record for Vera Cruz.

There appears to have been no damage of great consequence in the city of Vera Cruz, but news dispatches reported the loss of a number of small ships outside of the harbor, the largest of which was the 800-ton Mexican steamer *Dos Equis*, which sank with all hands lost, including a number of passengers.

This was the third and last storm movement of the month on the Atlantic side of the continent, with but one storm previously occurring on the Pacific coast. Before the Vera Cruz hurricane had crossed Yucatan, however, the second Pacific cyclone and the fifth tropical storm development of the month was in progress.

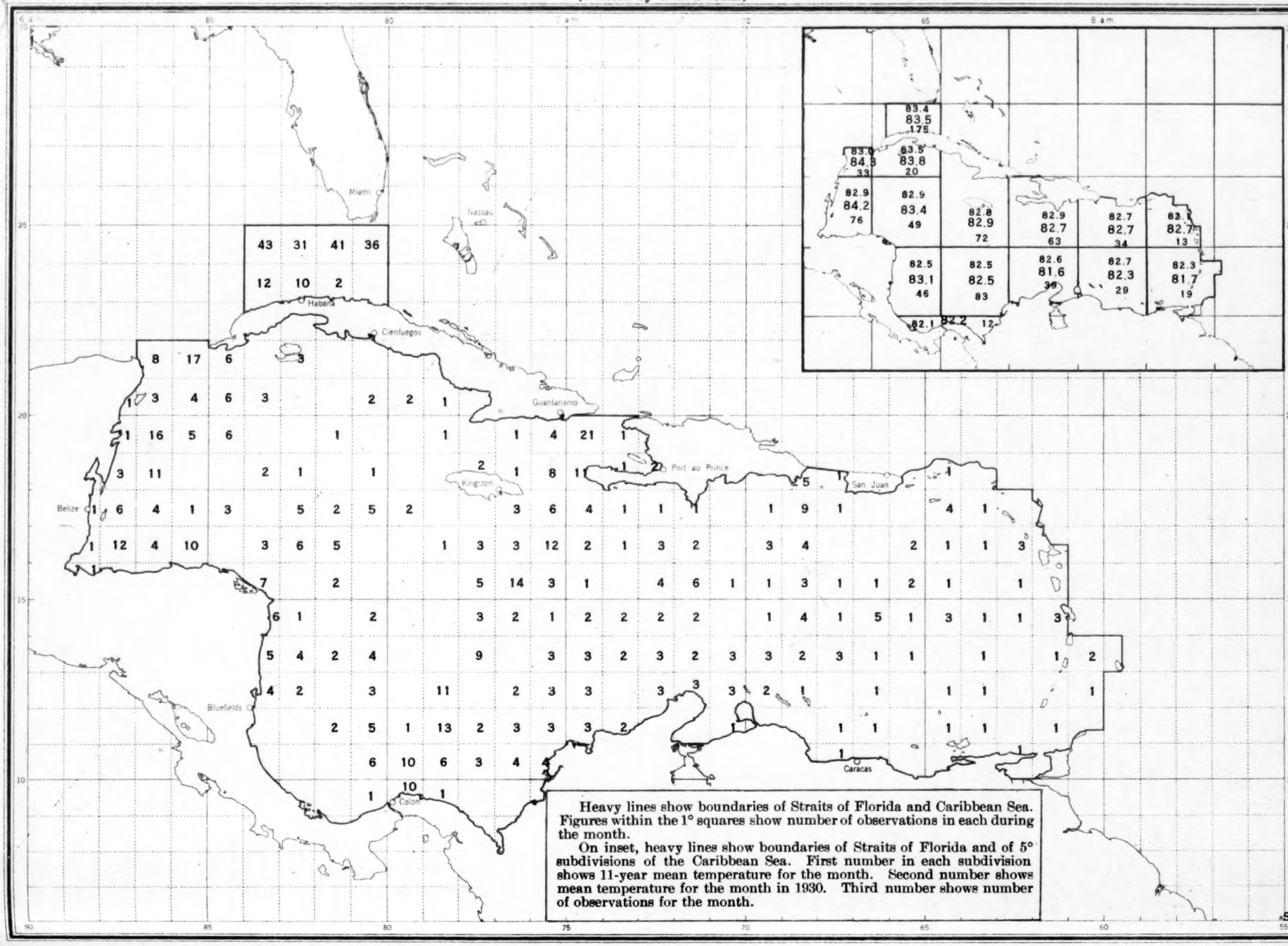
This cyclone closely followed its predecessor of a week before, appearing near 15° N., 100° W., early on the 14th, but it failed to develop the intensity of the first Pacific storm. At 8 a. m. of the 15th the American steamer *Willboro*, near 18° N., 104° W., met with a southeast gale of force 10, the highest noted for the storm. The lowest barometer reading reported was 29.54 inches, from the American steamer *San Felipe* in 17° 45′ N., 103° 25′ W., at 4 p. m. of the 14th. The last gale reported in connection with the storm was of fresh force and occurred near 20° N., 106° W. on the 17th. Thereafter the disturbance, as indicated by reports, seems to have been of slight force, yet it is quite possible that its accompanying seas were sufficiently rough to cause the final breaking up of the *Colombia* between the 18th and 20th.

The last two developments of the month, both in the Pacific, apparently originated in the same locality, about three or four hundred miles south of Acapulco, Mexico, and moved northwestward, approaching the peninsula of Lower California, to lose themselves finally by passing inland over extreme northwestern Mexico.

The earlier of the two and the sixth tropical disturbance of the month in American waters was first shown by observations on the 20th, when the British motor ship *Seminole* reported a barometer of 29.64 inches and fresh east gale near 17° 43′ N., 103° 19′ W. On the 21st the American steamer *Suriname* had a strong gale from ESE. near 19°

Distribution of Greenwich Mean Noon Bucket Observations of Sea-Surface Temperatures, September, 1931

(Plotted by Giles Slocum)



Heavy lines show boundaries of Straits of Florida and Caribbean Sea. Figures within the 1° squares show number of observations in each during the month.

On inset, heavy lines show boundaries of Straits of Florida and of 5° subdivisions of the Caribbean Sea. First number in each subdivision shows 11-year mean temperature for the month. Second number shows mean temperature for the month in 1930. Third number shows number of observations for the month.

N., 106° W. On the 22d the steamer *New Jersey* had a strong southeast gale near 21° N., 108° W., barometer depressed to 29.49 inches. On the 23d the steamer *Steel Age* had a southeast gale of force 11 near 23° N., 111° W., barometer 29.26 inches. On the 24th the steamer *Robin Hood* had a strong southeast gale near 25° N., 113° W. Thus, was shown the northwestward progress for five days of a storm that was at least of near-hurricane force off the west coast of Lower California.

The seventh cyclone was first indicated by reports as organizing on the 26th in the vicinity of 17° N., 103° W. It probably attained the height of its energy on the 27th, during which day the steamship *Willkeno* had a whole gale from ESE., barometer 29.60, near 19° N., 105° W., and the steamer *Charles R. McCormack* encountered strong northeast to southeast gales near 19° N. 106° W., with a maximum force of 12 from ESE. at noon, lowest pressure 29.13 inches. Captain Christensen of this vessel said the storm was accompanied by the heaviest precipitation of his experience. The storm proceeded northwestward with apparently lessening energy and was last heard from in connection with a moderate easterly gale on the 29th at about 23° N., 110° W.

BUCKET OBSERVATIONS OF SEA-SURFACE TEMPERATURES

By GILES SLOCUM

STRAITS OF FLORIDA AND CARIBBEAN SEA

Table 1 shows the average temperatures for the Caribbean Sea and the Straits of Florida for September of each year from 1919 to 1930, inclusive, and Table 2 summarizes the temperatures for September, 1930, in the same areas. The chart shows the number of observations taken in September, 1930, within each 1° square and mean temperature data for subdivisions of the area considered.

September is the warmest month in the Caribbean Sea, with the mean yearly peak in temperature occurring at approximately the end of the month. The Straits of Florida, while usually cooler in September than in August, are warmer than in July, and the temperatures there drop but slowly until the final days of the month, when the abrupt autumn drop in temperature ordinarily commences.

The last quarter of September, 1930, was slightly cooler than the 11-year mean in the Caribbean, but the month as a whole was warmer than the average, the seventh consecutive month of high temperatures. The Straits were close to the seasonal average in temperature, except in the final quarter, when they were above the mean.

TABLE 1.—*Mean sea-surface temperatures in the Caribbean Sea and the Straits of Florida for September, 1919–1930*

Year	Caribbean Sea		Straits of Florida	
	Number of observations	Mean (°F.)	Number of observations	Mean (°F.)
1919 [1]	87	82.6	28	82.2
1920	192	82.2	35	83.3
1921	255	82.1	104	83.4
1922	150	82.2	66	83.0
1923	237	82.0	71	83.1
1924	310	83.4	79	83.7
1925	384	82.7	131	83.6
1926	429	83.3	149	83.5
1927	547	83.6	180	84.3
1928	597	82.9	156	83.6
1929	644	82.5	176	82.8
1930	588	83.0	175	83.5
Mean (1920-1930)		82.7		83.4

[1] Not used in computations because of insufficient data available.

TABLE 2.—*Mean sea-surface temperatures (° F.) and number of observations, September, 1930*

Quarter	Period	Caribbean Sea				Straits of Florida			
		Number of observations	Mean	Departure from 11-year mean (1920-1930)	Change from preceding month	Number of observations	Mean	Departure from 11-year mean (1920-1930)	Change from preceding month
			°F.	°F.	°F.		°F.	°F.	°F.
First	Sept. 1-7	141	83.1			38	83.5		
Second	Sept. 8-15	169	82.9			51	83.4		
Third	Sept. 16-22	137	83.2			35	83.6		
Fourth	Sept. 23-30	141	82.6			51	83.5		
	Month	588	83.0	+0.3	+0.5	175	83.5	+0.1	−0.8

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, September, 1931

[For description of tables and charts, see REVIEW, January, p. 50]

Section	Temperature									Precipitation				
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	79.7	+4.2	Wetumpka	106	7	2 stations	42	[1] 28	1.23	−2.15	Samson	4.00	2 stations	T.
Arizona	74.7	+0.9	Gila Bend	115	[1] 11	do	23	[1] 20	1.64	+0.38	Henry's Camp	7.04	Granite Reef Dam	0.00
Arkansas	78.4	+4.2	3 stations	102	[1] 15	do	34	[1] 27	1.00	−2.36	Whitecliffs	4.32	Magnolia	0.00
California	65.7	−1.6	Brawley	114	7	Twin Lakes	17	[1] 9	0.18	−0.36	Cuyamaca	2.09	59 stations	0.00
Colorado	61.8	+4.0	Lamar	105	6	Telluride	9	25	1.46	+0.02	2 stations	4.73	Eads	0.00
Florida	80.3	+0.9	Bonifay	102	19	Vernon	47	29	5.32	−1.46	Miami	19.70	Raiford	0.01
Georgia	78.6	+3.2	Millen	107	18	Clayton	35	30	1.31	−2.43	Quitman	4.98	Hazelhurst	0.27
Idaho	57.7	+0.7	2 stations	104	3	Obsidian	18	22	0.98	−0.07	Coolin	2.85	Mountainhome	0.09
Illinois	73.1	+5.8	Sparta	103	17	Mount Carroll	36	28	4.77	+1.03	Paris	9.54	Cairo	1.19
Indiana	71.8	+4.8	Edwardsport	102	10	Delphi	34	29	4.75	+1.51	Terre Haute	9.64	Fort Wayne	2.08
Iowa	71.0	+6.7	Washta	105	7	4 stations	35	[1] 24	6.69	+3.02	Fort Dodge	12.68	Akron	2.68
Kansas	77.5	+8.2	2 stations	111	5	Atwood	31	26	2.50	−0.36	Emmett	9.35	Ness City	0.11
Kentucky	75.1	+4.7	Hopkinsville	103	18	2 stations	36	29	2.74	−0.09	Uniontown	5.94	Burnside	1.22
Louisiana	80.6	+2.7	Dodson	105	[1] 4	Robeline	39	29	1.88	−2.13	Donaldsonville	5.08	Logansport	0.00
Maryland-Delaware	72.2	+4.4	College Park, Md	100	22	Grantsville, Md	30	29	2.54	−0.68	Oakland, Md	5.32	Aberdeen, Md	0.83
Michigan	65.8	+5.7	East Tawas	101	11	3 stations	29	28	5.06	+1.73	Mackinac Island	10.75	South Haven	1.94
Minnesota	64.9	+6.7	Beardsley	111	11	2 stations	26	[1] 24	2.55	−0.48	Grand Meadow	7.34	Wheaton	0.62
Mississippi	79.7	+3.9	Columbus	103	24	do	41	29	0.78	−2.25	Laurel	3.84	5 stations	0.00
Missouri	75.0	+6.0	2 stations	104	[1] 5	3 stations	36	[1] 29	4.16	+0.32	King City	10.80	Dean	0.46
Montana	57.2	+1.9	3 stations	101	6	Upper Yaak River	16	23	1.66	+0.40	Babb (near)	3.83	Melstone	0.09
Nebraska	71.0	+7.1	Imperial	110	5	2 stations	30	[1] 22	2.28	+0.13	Falls City	8.50	Sutherland	0.20
Nevada	61.8	−0.8	Clay City	112	3	Zorra Vista Ranch	13	24	0.53	+0.14	Lamoille	1.72	3 stations	0.00
New England	62.7	+2.5	4 stations	97	11	Garfield, Vt	27	30	3.26	−0.31	West Burke, Vt	8.73	Westfield, Mass	0.69
New Jersey	70.5	+5.0	2 stations	100	[1] 11	3 stations	34	29	1.98	−1.54	Sussex	3.15	Runyon	0.86
New Mexico	67.1	+2.9	Nara Visa (near)	103	14	Selsor Ranch	21	25	2.50	+0.93	Winsors Ranch	8.36	2 stations	0.00
New York	65.2	+4.1	2 stations	101	[1] 10	Indian Lake	27	29	3.86	+0.45	High Market	8.26	Cutchogue	1.09
North Carolina	74.1	+3.2	Fayetteville	106	18	Banners Elk	27	29	1.71	−2.27	Tarboro	6.69	Monroe	0.00
North Dakota	61.4	+5.0	3 stations	107	[1] 6	3 stations	27	[1] 17	2.14	+0.49	Park River	4.63	Power	0.35
Ohio	70.3	+4.7	Portsmouth	99	21	2 stations	33	29	4.01	+1.03	Hillsboro	7.61	Dam No. 28, Ohio River.	1.56
Oklahoma	80.9	+7.0	Jefferson	110	5	do	40	[1] 27	1.17	−2.12	Bartlesville	6.78	2 stations	0.00
Oregon	56.8	0.0	Echo	104	3	Blitzen	13	[1] 9	0.99	−0.21	Astoria	5.36	4 stations	T.
Pennsylvania	69.1	+5.0	2 stations	104	[1] 12	2 stations	29	[1] 29	3.15	−0.31	Saltsburg	6.65	Marcus Hook	0.74
South Carolina	77.5	+3.0	do	107	18	Clemson College	40	28	0.98	−3.14	Beaufort (near)	3.27	Newberry	T.
South Dakota	68.1	+7.2	Gannvalley	112	9	2 stations	29	[1] 23	1.42	−0.37	Sioux Falls	4.28	Dumont	0.04
Tennessee	76.4	+5.1	2 stations	103	[1] 18	Crossville	32	29	1.51	−1.56	Tiftonville	3.99	Selmer	0.02
Texas	81.4	+4.0	3 stations	107	[1] 5	2 stations	43	[1] 22	0.68	−2.19	Jefferson	5.69	20 stations	0.00
Utah	62.1	+1.5	St. George	101	[1] 6	Widtsoe	14	19	0.53	−0.52	Monticello	2.14	Leeds	0.00
Virginia	72.8	+4.4	2 stations	101	22	Burkes Garden	30	29	2.46	−0.63	Christchurch	6.17	Martinsville	0.65
Washington	57.9	−0.1	do	102	[1] 2	Stockdill Ranch	21	23	2.85	+1.04	Big Four	16.32	3 stations	0.04
West Virginia	70.0	+4.0	do	102	[1] 12	Bayard	29	29	3.91	+0.87	Rowlesburg	6.70	Dam No. 25, Ohio River.	1.45
Wisconsin	66.0	+6.2	do	103	10	4 stations	29	[1] 24	5.81	+2.11	Manitowoc	11.83	Iron River	2.22
Wyoming	57.3	+2.9	Worland	102	7	Dome Lake	8	23	1.06	−0.21	2 stations	2.70	Lusk	0.10
Alaska (August)	52.9	−0.3	Skagway	85	10	Eagle	22	27	3.74	−0.09	Mount Roberts (a)	20.34	Barrow	0.43
Hawaii	75.1	+0.5	Kaanapali	96	6	Kanalohuluhulu	49	12	10.14	+4.20	Hiloa-Manawaiopuna Divide.	52.00	Mahukona	0.00
Porto Rico	79.3	+0.4	Mayaguez	95	7	Juncos	60	11	12.76	+4.72	Maricao	27.75	Ensenada	5.51

[1] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, September, 1931*

District and station	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Departure from normal	Days with 0.01 or more	Wind: Total movement	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England							**64.2**	**+3.4**										**80**	**2.76**	**−0.4**										**5.0**		
Eastport	76	67	85	29.87	29.95	−0.08	56.0	+0.2	73	11	62	41	19	50	20	53	50	84	3.61	+0.8	15	5,979	nw.	28	nw.	25	8	4	18	6.7	0.0	0.0
Greenville, Me.	1,070	6		28.81	29.96		56.0		88	11	65	32	30	47	36	52		86	3.93		16	4,057	se.	20		25	7	10	13		0.0	0.0
Portland, Me.	103	82	117	29.85	29.97	−.08	63.2	+3.6	95	11	71	45	30	55	31	56	53	76	2.95	−0.2	10	5,521	nw.	26	nw.	24	15	8	7	4.3	0.0	0.0
Concord	289	70	79	29.67	29.97	−.09	62.8	+3.5	94	11	74	33	30	52	37				2.70	−0.8	9	3,215	n.	21	nw.	8	11	11	8	5.0	0.0	0.0
Burlington	403	11	48	29.53	29.96	−.10	62.4	+2.1	95	11	71	36	29	53	31				3.86	+0.4	14	5,827	s.	36	sw.	17	6	10	14	6.3	0.0	0.0
Northfield	876	12	60		30.00	−.06	59.5	+3.4	92	11	70	29	20	49	40			86	3.81	+0.7	14	4,115	s.	23	sw.	6	5	13	12	6.7	0.0	0.0
Boston	125	106	165	29.85	29.98	−.09	66.9	+3.7	95	11	75	46	29	59	33	60	56	73	1.67	−1.5	8	5,145	nw.	27	nw.	24	16	7	7	4.3	0.0	0.0
Nantucket	12	14	90	29.97	29.98	−.10	65.6	+2.8	88	11	72	52	25	60	20	61	58	82	2.84	+0.4	8	10,427	sw.	36	ne.	28	14	7	9	5.1	0.0	0.0
Block Island	26	11	46	29.96	29.99	−.09	66.0	+2.6	84	11	71	50	29	61	15	62	59	80	1.93	−0.7	7	10,332	sw.	39	w.	24	15	8	7	4.1	0.0	0.0
Providence	160	215	251	29.82	29.99	−.08	67.3	+4.1	94	11	77	44	30	58	31	61	58	77	1.37	−1.8	6	7,067	nw.	38	nw.	24	17	5	8	4.0	0.0	0.0
Hartford	159	122		29.83	30.00	−.07	67.8	+6.1	95	10	77	42	30	58	30				1.05	−2.4	10		sw.				13	9	8	4.4	0.0	0.0
New Haven	106	74	153	29.89	30.00	−.07	69.2	+5.7	95	11	78	45	29	60	29	63	59	76	4.60	+1.1	9	5,466	s.	24	s.	20	14	8	8	4.5	0.0	0.0
Middle Atlantic States							**72.2**	**+5.1**										**75**	**2.02**	**−1.2**										**4.0**		
Albany	97	107	115	29.89	29.99	−.08	67.0	+3.9	98	11	76	42	29	58	32	60	57	77	1.91	−1.2	9	4,370	s.	20	s.	17	16	5	9	4.5	0.0	0.0
Binghamton	871	10	84	29.10	30.02	−.05	67.4	+6.1	96	12	79	38	29	56	39				2.11	−1.0	10	3,269	nw.	20	ne.	15	9	9	12	5.6	0.0	0.0
New York	314	414	454	29.67	30.00	−.08	71.2	+4.4	95	11	79	48	29	64	23	63	59	72	1.15	−2.2	6	9,159	n.	46	nw.	24	14	9	7	4.3	0.0	0.0
Bellefonte	1,050	5	36	28.93	30.03		66.9		94	12	80	33	29	54	39	61	58	78	2.46		9		sw.	34	se.	26	9	9	12	5.4	0.0	0.0
Harrisburg	374	94	104	29.62	30.01	−.07	72.1	+6.3	97	11	82	48	29	63	30	63	59	70	3.35	+0.3	7	3,803	w.	35	w.	2	16	6	8	4.2	0.0	0.0
Philadelphia	114	123	367	29.90	30.03	−.05	74.1	+6.1	97	11	82	50	29	66	23	65	61	68	1.60	−1.5	4	8,266	sw.	36	nw.	24	13	10	7	4.0	0.0	0.0
Reading	325	81	98	29.68	30.02		72.0	+5.7	99	12	82	46	29	62	33	64	60	72	2.79	−0.4	4	2,889	sw.	31	sw.	2	15	8	7	4.2	0.0	0.0
Scranton	805	72	103	29.18	30.03	−.04	68.4	+5.5	97	12	79	41	29	57	35	62	59	79	2.09	−1.1	9	3,772	sw.	26	nw.	24	13	10	7	4.4	0.0	0.0
Atlantic City	52	37	172	29.96	30.01	−.06	72.3	+5.5	94	11	79	49	29	66	24	66	63	79	2.55	−0.1	5	10,053	sw.	38	s.	20	17	8	5	3.3	0.0	0.0
Cape May	17	13	49				72.4	+3.4	93	11	80	48	29	65	25	67	65	81	3.13	+0.1	6		nw.				14	11	5		0.0	0.0
Sandy Hook	22	10	55	29.97	29.99		71.9		94	11	78	53	29	65	21	65	62	77	0.97	−2.5	7	9,048	sw.	37	nw.	24	15	8	7	4.4	0.0	0.0
Trenton	190	159	183	29.81	30.01		71.4	+4.5	95	11	81	46	29	62	28	64	61	74	1.06	−2.3	4	5,823	sw.	28	nw.	24	16	7	7	4.0	0.0	0.0
Baltimore	123	100	215	29.89	30.02	−.06	76.0	+7.5	99	22	85	50	29	67	25	66	62	66	2.05	−1.3	7	6,093	sw.	42	sw.	23	17	7	6	3.5	0.0	0.0
Washington	112	62	85	29.91	30.03	−.05	74.1	+6.0	97	22	84	49	29	64	28	66	63	75	2.79	−0.4	9	3,199	sw.	33	nw.	23	18	6	6	3.6	0.0	0.0
Cape Henry	18	8	54	30.02	30.04		76.4	+4.6	95	22	84	53	30	69	22	69	66	76	2.70	−0.2	4	7,273	sw.	44	nw.	23	18	10	2	3.1	0.0	0.0
Lynchburg	681	153	188	29.32	30.06	−.02	73.8	+4.8	96	22	85	46	30	63	31	65	62	73	0.73	−2.6	5	3,225	w.	34	n.	23	17	8	5	3.7	0.0	0.0
Norfolk	91	170	205	29.96	30.06	.00	76.4	+4.8	96	23	85	57	30	68	28	68	64	74	1.45	−1.8	6	7,262	sw.	42	nw.	23	17	9	4	3.5	0.0	0.0
Richmond	144	11	52	29.91	30.06	−.01	74.4	+3.9	97	22	85	46	30	64	30	68	66	82	1.92	−1.3	4	4,111	sw.	31	n.	23	17	7	6	3.4	0.0	0.0
Wytheville	2,304	49	55	27.76	30.08	+.01	67.6	+4.0	89	21	80	38	30	56	31	61	59	80	2.06	−1.2	8	2,721	w.	18	w.	26	17	11	2	3.8	0.0	0.0
South Atlantic States							**77.4**	**+4.1**										**75**	**1.22**	**−3.0**										**3.6**		
Asheville	2,253	89	104	27.80	30.09	+.02	71.0	+6.0	91	21	83	38	29	59	35	63	60	78	1.12	−1.9	3	3,637	nw.	20	nw.	27	15	13	2	3.7	0.0	0.0
Charlotte	779	55	62	29.25	30.07	.00	77.0	+5.5	98	18	88	46	30	67	27	67	63	68	1.15	−1.8	3	2,438	s.	14	w.	2	18	11	1	3.1	0.0	0.0
Greensboro	886	6	56	29.14	30.08		73.4		97	23	85	42	30	62	33	66	64	82	0.51		3	4,246	sw.	24	sw.	26	15	8	7	4.1	0.0	0.0
Hatteras	11	5	50	30.04	30.05	−.01	77.2	+2.5	90	18	83	63	28	71	21	72	70	80	1.70	−2.9	6	7,287	sw.	35	nw.	28	17	8	5	3.4	0.0	0.0
Raleigh	376	103	146	29.68	30.06	−.01	76.2	+5.1	97	23	86	48	30	66	26	67	63	70	2.37	−1.2	3	4,535	sw.	23	n.	23	17	10	3	3.6	0.0	0.0
Wilmington	78	81	91	30.01	30.09	+.04	76.8	+3.7	98	18	86	52	30	68	24	70	67	79	0.12	−4.4	1	3,732	sw.	18	sw.	26	22	6	2	2.9	0.0	0.0
Charleston	48	11	92	30.02	30.06	+.02	78.7	+2.1	98	18	85	56	28	72	23	73	70	80	2.08	−2.4	5	6,311	e.	26	e.	19	15	10	5	4.0	0.0	0.0
Columbia, S. C.	351	41	57	29.70	30.07	+.02	78.6	+4.1	99	18	89	52	29	68	27	68	63	68	0.56	−2.9	3	3,917	s.	20	sw.	26	20	7	3	3.1	0.0	0.0
Due West	711	10	55	29.34	30.10		77.5		99	18	89	48	28	66	28				0.84		6	4,445	sw.	25	nw.	2	15	11	4	3.7	0.0	0.0
Greenville, S. C.	1,039	139	146	29.00	30.07		77.1	+6.5	97	18	86	51	30	68	24	66	62	66	2.62	−1.1	7	4,291	n.	26	w.	2	19	8	3	3.1	0.0	0.0
Augusta	182	62	77	29.86	30.05	.00	80.2	+4.9	104	18	92	52	28	69	33	70	66	71	0.40	−3.0	3	2,774	se.	18	nw.	3	19	10	1	3.2	0.0	0.0
Savannah	65	150	194	29.98	30.05	+.02	79.2	+3.0	100	18	88	56	29	71	27	72	70	81	1.25	−4.2	6	6,291	e.	28	w.	26	16	9	5	4.1	0.0	0.0
Jacksonville	43	209	245	29.99	30.04	+.04	80.0	+1.7	95	19	87	60	28	73	21	73	70	80	0.07	−7.3	2	6,675	ne.	27	ne.	30	12	15	3	4.4	0.0	0.0
Florida Peninsula							**81.1**	**+0.4**										**82**	**12.47**	**+5.3**										**6.3**		
Key West	22	10	64	29.93	29.95	+0.1	82.0	−0.2	90	9	87	70	6	77	15	77	75	81	9.10	+2.4	15	5,848	e.	29	w.	28	7	12	11	6.0	0.0	0.0
Miami	25	124	168	29.96	29.99	+.01	81.2	+1.1	90	11	86	70	6	76	16	75	73	80	19.70	+11.4	20	6,423	e.	30	s.	7	1	14	15	7.3	0.0	0.0
Tampa	35	79	197	29.97	30.00	+.03	80.3	+0.4	93	2	88	62	28	72	21	74	72	84	8.61	+2.2	21	6,848	e.	35	ne.	10	4	14	12	6.2	0.0	0.0
Titusville	44	5		29.97	30.02		81.4		95	3	89	62	29	74	21				3.01		12		ne.				4	20	6	5.6	0.0	0.0
East Gulf States							**79.8**	**+4.1**										**72**	**1.30**	**−2.9**										**3.4**		
Atlanta	1,173	190	198	28.86	30.07	+.02	77.5	+5.1	97	18	87	50	28	68	26	66	61	64	1.32	−1.7	3	4,886	e.	24	w.	26	17	11	2	3.4	0.0	0.0
Macon	370	78	87	29.67	30.06	+.03	78.4	+3.6	99	18	89	51	28	68	31	69	66	72	2.50	−0.7	5	2,968	e.	18	nw.	27	18	8	4	3.3	0.0	0.0
Thomasville	273	49	103	29.75	30.04	+.03	79.4	+2.6	100	19	90	53	28	69	28	71	68	76	2.08	−2.8	7	3,939	ne.	24	s.	2	17	8	5	3.9	0.0	0.0
Apalachicola	36	11	51	29.99	30.03		79.9		92	19	86	58	28	74	20	74	71	77	2.41	−5.7	10	5,102	se.	29	e.	14	21	3	6	3.0	0.0	0.0
Pensacola	56	149	185	29.97	30.03	+.04	79.4	+1.4	92	7	85	57	28	74	17	73	70	78	1.43	−3.9	4	7,086	s.	30	nw.	3	14	14	2	3.7	0.0	0.0
Anniston	741	9	57				78.6	+7.3	101	19	91	48	28	66	31				0.79	−2.9	2	2,349	s.	13	nw.	27	14	14	2		0.0	0.0
Birmingham	700	11	48	29.30	30.06	+.03	81.0	+6.2	102	19	93	50	28	69	30	68	63	66	0.14	−3.2	4	3,241	se.	19	se.	23	16	13	1	3.3	0.0	0.0
Mobile	57	125	161	29.97	30.03	+.03	80.4	+2.3	96	8	89	54	29	72	27	72	70	80	1.92	−3.1	8	5,083	n.	25	n.	3	14	12	4	3.8	0.0	0.0
Montgomery	223	100	112	29.80	30.05	+.03	81.0	+4.7	100	7	92	54	29	70	27	69	64	64	0.63	−2.4	5	3,384	e.	24	e.	14	19	8	3	3.3	0.0	0.0
Corinth	469	6					80.0		100	17	94	45	29	67	38				0.14		1		se.				14	16	0		0.0	0.0
Meridian	375	87	95	29.65	30.03	+.01	79.2	+4.7	97	24	90	47	29	68	32	70	66	70	0.23	−2.7	4	2,586	se.	14	sw.	2	18	10	2	3.3	0.0	0.0
Vicksburg	247	65	73	29.77	30.05	+.03	80.3	+4.0	96	9	91	52	29	70	29	70	66	69	0.08	−2.8	3	3,469	se.	17	se.	5	18	12	0	3.0	0.0	0.0
New Orleans	53	76	84	29.96	30.01	+.03	82.3	+3.1	96	8	90	62	28	75	22	74	72	78	2.06	−3.0	8	3,706	se.	20	e.	5	12	14	4	4.0	0.0	0.0
West Gulf States							**81.5**	**+4.5**										**70**	**1.15**	**−2.5**										**3.1**		
Shreveport	249	204	220	29.74	30.00	.00	82.1	+5.2	90	5	93	58	27	71	29	70	65	65	0.74	−2.1	5	5,337	s.	36	sw.	3	22	7	1	2.7	0.0	0.0
Bentonville	1,303	11	44	28.66	29.99	−.03	76.1	+7.2	95	18	88	43	27	64	33				0.53		5	2,353	s.	17	s.	21	26	4	0		0.0	0.0
Fort Smith	457	79	94	29.51	29.98	−.03	79.5	+5.5	97	17	90	50	27	69	31	69	66	69	0.77	−2.2	4	4,027	e.	30	se.	12	24	5	1	2.5	0.0	0.0
Little Rock	357	136	153	29.64	30.01	−.02	79.9	+5.8	96	25	90	54	30	70	29	70	65	68	0.64	−2.5	6	4,597	s.	24	s.	4	19	9	2	2.8	0.0	0.0
Austin	605	136	148	29.34	29.97		83.0	+4.7	98	5	94	58	30	72	29	70	66	65	0.02	−3.4	1	4,277	se.	28	se.	12	13	17	0	3.7	0.0	0.0
Brownsville	57	83	100	29.88	29.95		82.0	+1.4	92	3	89	70	29	75	19	75	73	83	1.43	−4.1	11	5,159	e.	26	se.	1	10	18	2	4.3	0.0	0.0
Corpus Christi	20	11	78	29.95	29.97	+.02	83.1	+3.4	90	20	88	74	30	78	14	76	74	80	0.83	−3.7	9	6,507	se.	24	se.	12	17	9	4	3.9	0.0	0.0
Dallas	512	220	227	29.44	29.98		82.0		100	5	92	58	30	72	25				2.76	0.0	2	6,930	se.	27	se.	20	24	5	1	1.7	0.0	0.0
Fort Worth	670	106	114	29.25	29.96	−.03	83.0	+6.1	101	4	94	59	30	72	26	69	62	56	1.25	−1.2	2	5,635	s.	27	se.	20	23	5	2	3.0	0.0	0.0
Galveston	54	106	114	29.96	30.02	+.04	82.4	+2.3	94	9	86	70	29	78	16	75	72	76	0.94	−4.6	8	6,162	se.	21	e.	27	20	7	3	3.2	0.0	0.0
Houston	138	292	314	29.85	30.00		81.6	+2.6	97	3	90	59	29	73	26				2.27	−1.8	5	6,528	se.	35	e.	10	18	10	2	3.2	0.0	0.0
Palestine	510	64	72	29.48	30.00	+.01	81.3	+4.3	97	25	92	55	30	70	29	70	65	67	0.01	−2.9	1	4,038	s.	20	s.	12	19	10	1	2.8	0.0	0.0
Port Arthur	34	58	66	29.96	30.00		82.0		97	9	90	64	29	74	23	74	71	76	2.03	−2.8	10	4,470	s.	41	e.	5	16	12	2	3.2	0.0	0.0
San Antonio	693	242	301	29.24	29.94	−.02	83.2	+4.2	98	4	94	65	30	73	26	72	67	68	0.01	−3.0	1	7,075	e.	42	e.	12	15	15	0	3.3	0.0	0.0
Taylor	571	38	51	29.42	30.02	+.05	82.6	+5.7	100	5	94	58	30	71	32				2.40	−0.9	3	4,727	s.	29	s.	12	18	11	1	3.3	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, September, 1931*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							73.9	+5.2										72	3.34	+0.4										4.0		
Chattanooga	762	190	215	29.25	30.04	−0.02	278.2	+6.0	97	18	89	50	30	67	30	67	61	62	0.51	−2.6	5	3,932	se.	24	sw.	2	16	12	2	3.5	0.0	0.0
Knoxville	995	102	111	29.03	30.07	+.01	76.8	+6.2	98	18	88	47	29	65	30	66	62	69	1.95	−0.7	4	3,163	sw.	30	se.	19	20	8	2	3.2	0.0	0.0
Memphis	399	76	97	29.61	30.03	.00	79.8	+6.2	96	10	89	52	27	71	27	69	65	66	0.57	−2.2	2	4,387	s.	25	sw.	25	21	7	2	3.0	0.0	0.0
Nashville	546	168	191	29.49	30.06	.00	77.2	+5.4	98	18	88	46	29	66	34	67	63	69	1.54	−1.9	6	4,514	ne.	28	nw.	25	13	13	4	3.6	0.0	0.0
Lexington	989	193	230	29.03	30.08	+.01	73.4	+4.9	93	21	82	47	29	64	32	----	----	----	2.15	−0.9	8	7,356	s.	31	nw.	25	20	6	4	2.9	0.0	0.0
Louisville	525	188	234	29.48	30.06	.00	75.2	+4.7	94	21	84	49	28	66	31	66	62	70	3.56	+0.8	6	5,476	s.	33	n.	27	14	11	5	3.9	0.0	0.0
Evansville	431	76	116	29.58	30.04	−.02	76.2	+5.5	96	17	86	50	30	66	30	67	63	71	4.45	+1.1	5	4,776	s.	28	sw.	25	16	9	5	3.8	0.0	0.0
Indianapolis	822	194	230	29.16	30.03	−.03	72.8	+5.9	92	11	82	47	28	64	28	64	60	72	3.66	+0.3	9	6,073	sw.	30	nw.	3	17	7	6	3.9	0.0	0.0
Royal Center	736	11	55	29.24	30.03	------	69.2	------	93	11	80	38	28	59	32	----	----	----	4.16	+1.3	10	4,892	s.	24	nw.	26	13	10	7	4.7	0.0	0.0
Terre Haute	575	96	129	29.42	30.02	------	73.2	------	93	17	83	46	28	64	27	65	62	76	9.64	+6.0	8	5,130	s.	26	sw.	1	14	10	6	4.1	0.0	0.0
Cincinnati	627	11	51	29.38	30.06	−.01	72.7	+5.6	94	10	83	42	29	62	32	64	61	76	4.71	+2.1	8	3,556	sw.	17	sw.	25	16	8	6	3.8	0.0	0.0
Columbus	822	216	230	29.18	30.04	−.03	71.4	+4.9	92	10	81	45	28	62	27	63	60	73	3.34	+0.8	12	5,700	s.	34	sw.	23	14	9	7	4.2	0.0	0.0
Dayton	899	137	173	29.10	30.04	------	72.0	+5.4	93	11	82	44	28	62	29	64	60	74	2.36	−0.6	8	4,593	sw.	28	sw.	23	12	13	5	4.1	0.0	0.0
Elkins	1,947	59	67	28.09	30.11	+.03	66.3	+3.3	90	12	78	39	30	55	35	60	59	80	3.82	+0.7	14	2,435	w.	28	sw.	2	7	14	9	6.0	0.0	0.0
Parkersburg	637	77	82	29.43	30.08	.00	72.4	+5.1	95	12	82	44	30	62	33	64	60	74	3.27	+0.5	11	2,925	se.	32	nw.	25	12	10	8	5.0	0.0	0.0
Pittsburgh	842	353	410	29.16	30.04	−.04	70.3	+3.9	93	12	79	42	29	61	27	63	59	73	3.81	+1.2	11	5,768	sw.	31	sw.	23	11	9	10	4.9	0.0	0.0
Lower Lake Region							68.4	+5.5										73	3.25	+0.3										5.1		
Buffalo	767	247	280	29.18	29.99	−.07	66.4	+4.0	83	13	73	45	25	60	22	61	58	78	4.10	+1.2	9	9,087	sw.	56	w.	1	11	9	10	5.2	0.0	0.0
Canton	448	10	61	29.49	29.96	------	62.9	+3.6	90	13	73	37	25	53	32	----	----	----	5.69	+2.3	15	4,821	sw.	26	w.	22	10	13	7	5.3	0.0	0.0
Ithaca	836	74	100	29.11	30.00	------	67.8	+6.2	100	12	80	39	25	56	40	60	56	71	2.99	−0.1	10	5,287	nw.	26	sw.	2	10	12	8	5.1	0.0	0.0
Oswego	335	71	85	29.62	29.98	−.08	66.8	+5.6	93	13	75	47	30	59	32	60	57	73	2.73	0.0	15	5,174	s.	22	nw.	24	9	9	12	5.6	0.0	0.0
Rochester	523	86	102	29.45	30.01	−.05	68.1	+5.7	95	12	78	42	25	58	32	60	56	71	2.85	+0.4	12	4,881	sw.	29	w.	22	8	13	9	5.3	0.0	0.0
Syracuse	596	65	79	29.37	30.01	−.06	68.6	+7.0	97	11	78	42	25	59	35	----	----	----	2.76	0.0	12	3,909	s.	20	w.	24	8	11	11	6.3	0.0	0.0
Erie	714	130	166	29.25	30.01	−.05	69.2	+5.6	92	13	77	46	29	61	27	62	59	74	2.27	−1.1	11	8,016	s.	41	sw.	1	12	10	8	4.6	0.0	0.0
Cleveland	762	267	337	29.21	30.02	−.04	69.8	+5.9	90	21	76	51	29	63	20	62	58	70	3.93	+0.6	12	8,363	s.	40	se.	25	10	12	8	5.2	0.0	0.0
Sandusky	629	5	67	29.35	30.03	−.03	70.6	+5.3	95	11	79	45	29	62	26	----	----	----	3.63	+0.7	9	4,787	sw.	28	sw.	1	11	8	11	5.3	0.0	0.0
Toledo	628	208	243	29.35	30.03	−.03	70.2	+5.8	95	11	78	44	28	62	25	62	58	71	3.23	+0.4	11	7,861	sw.	31	s.	14	15	7	8	4.4	0.0	0.0
Fort Wayne	856	100	119	29.11	30.02	------	70.5	+5.0	95	11	80	46	28	61	30	62	59	73	2.08	−1.0	8	5,316	sw.	26	w.	26	16	7	7	4.3	0.0	0.0
Detroit	730	218	258	29.24	30.02	−.04	69.8	+6.3	95	11	78	48	28	62	25	62	59	73	2.97	+0.1	11	6,017	sw.	29	sw.	1	11	11	8	5.1	0.0	0.0
Upper Lake Region							65.6	+6.1										78	4.69	+1.4										5.1		
Alpena	609	13	92	29.33	29.99	−.04	63.8	+6.2	98	11	74	41	28	54	32	58	56	81	4.34	+1.4	16	6,840	nw.	38	se.	25	10	12	8	4.8	0.0	0.0
Escanaba	612	54	60	29.30	29.95	−.06	63.4	+6.3	87	9	71	42	27	56	27	58	56	81	6.88	+3.6	12	6,002	s.	34	ne.	26	13	10	7	4.6	0.0	0.0
Grand Haven	632	54	89	29.31	29.98	−.06	65.6	+4.7	85	11	73	41	28	58	26	61	59	80	3.42	−0.2	12	7,094	s.	37	sw.	1	14	7	9	4.9	0.0	0.0
Grand Rapids	707	70	244	29.24	30.00	−.05	69.0	+6.3	94	10	79	44	28	59	30	61	57	74	4.09	+0.6	10	7,227	sw.	44	sw.	22	9	12	9	5.2	0.0	0.0
Houghton	668	64	90	29.20	29.92	−.08	63.3	+6.4	98	11	71	46	28	55	32	----	----	----	3.66	+0.1	14	5,763	w.	35	nw.	13	8	12	10	5.9	0.0	0.0
Lansing	878	6	88	29.07	30.00	------	66.5	+5.1	93	11	77	38	28	56	32	61	59	83	3.33	+0.4	14	4,920	sw.	23	sw.	5	9	12	9	5.4	0.0	0.0
Ludington	637	60	66	29.29	29.98	------	65.2	+5.9	83	10	72	46	28	59	26	60	58	80	6.87	+3.6	12	6,664	s.	34	sw.	1	13	13	4	3.9	0.0	0.0
Marquette	734	77	111	29.14	29.94	−.06	64.5	+7.0	98	11	72	46	24	57	27	57	54	76	5.66	+2.4	15	6,211	w.	30	sw.	29	10	8	12	6.0	0.0	0.0
Port Huron	638	70	120	29.30	29.99	−.07	67.4	+5.8	98	11	76	45	28	59	28	61	58	77	2.92	+0.1	12	6,507	s.	26	nw.	14	9	11	10	5.3	0.0	0.0
Sault Ste. Marie	614	11	52	29.29	29.98	−.04	60.9	+5.4	92	10	69	41	25	53	31	56	54	83	6.72	+2.5	16	4,320	se.	22	nw.	17	10	14	6	5.1	0.0	0.0
Chicago	673	7	131	29.29	30.01	−.03	71.2	+6.0	94	10	79	50	29	63	27	63	60	76	5.14	+2.0	13	6,107	sw.	26	sw.	5	12	10	8	4.9	0.0	0.0
Green Bay	617	109	141	29.29	29.95	−.07	67.2	+6.8	97	10	76	45	27	58	29	60	56	74	5.84	+2.3	14	6,494	s.	30	ne.	14	9	11	10	5.8	0.0	0.0
Milwaukee	681	125	221	29.25	29.98	−.05	69.6	+7.1	97	10	78	48	27	61	31	62	58	74	3.15	−0.1	10	8,224	sw.	39	w.	13	13	10	7	4.7	0.0	0.0
Duluth	1,133	5	47	28.70	29.91	−.07	61.4	+6.3	92	8	70	37	24	52	30	54	51	79	3.63	+0.3	13	6,802	ne.	34	nw.	23	12	10	8	5.0	0.0	0.0
North Dakota							62.3	+5.1										66	1.86	+0.2										3.5		
Moorhead	940	50	58	28.86	29.86	−.10	64.9	+6.7	101	7	77	31	24	52	40	55	49	66	1.64	−0.6	11	5,210	s.	30	sw.	11	14	11	5	4.0	0.0	0.0
Bismarck	1,674	8	57	28.09	29.85	−.09	63.2	+5.1	105	7	77	37	26	50	46	53	46	64	2.81	+1.6	8	5,692	e.	31	nw.	29	21	5	4	2.6	0.0	0.0
Devils Lake	1,478	11	44	28.30	29.86	−.08	60.4	+4.5	99	7	73	36	24	48	38	52	47	73	2.72	+1.1	7	5,575	se.	28	ne.	8	15	9	6	4.3	0.0	0.0
Ellendale	1,457	10	56	28.32	29.86	------	64.2	------	103	10	80	33	24	49	49	----	----	----	0.89	−1.1	6	8,120	nw.	34	sw.	29	17	9	4	3.4	0.0	0.0
Grand Forks	833	12	67	------	------	------	62.0	------	100	7	76	35	24	48	40	53	----	----	2.44	------	9	------	se.	31	sw.	11	14	12	4	----	0.0	0.0
Williston	1,878	41	48	27.90	29.85	−.08	60.8	+4.2	99	6	74	36	23	48	42	50	43	60	1.23	+0.1	8	5,101	w.	31	se.	18	19	7	4	3.0	0.0	0.0
Upper Mississippi Valley							72.0	+6.9										73	4.48	+0.9										4.4		
Minneapolis	918	102	208	28.92	29.89	------	68.6	+7.2	104	10	78	43	24	59	31	----	----	----	2.42	−0.7	12	6,877	s.	26	se.	24	12	10	8	4.7	0.0	0.0
St. Paul	837	114	149	29.01	29.90	−.09	68.2	+6.9	101	10	78	42	24	58	32	----	----	----	2.56	−0.5	13	4,969	sw.	35	sw.	21	13	8	9	4.6	0.0	0.0
La Crosse	714	11	48	29.18	29.94	−.07	68.5	+6.3	99	10	79	41	27	58	33	----	----	----	3.75	−0.2	14	2,781	s.	16	s.	21	13	8	9	4.6	0.0	0.0
Madison	974	70	78	28.94	29.96	−.07	68.4	+6.0	95	10	77	46	27	58	29	61	57	74	7.17	+3.4	14	4,967	s.	26	sw.	20	12	9	9	4.7	0.0	0.0
Wausau	1,247	4	62	28.64	29.96	------	65.4	------	99	10	76	37	27	55	33	----	----	----	3.70	0.0	14	3,635	s.	18	w.	5	17	5	8	4.4	0.0	0.0
Charles City	1,015	10	51	28.89	29.95	−.05	69.0	+8.0	98	10	80	40	24	58	35	60	57	73	7.40	+3.7	11	4,360	se.	19	s.	11	12	12	6	4.4	0.0	0.0
Davenport	606	71	79	29.33	29.98	−.05	72.4	+6.8	91	9	82	46	27	63	29	64	60	71	3.78	+0.2	10	5,707	s.	27	s.	13	12	7	11	5.1	0.0	0.0
Des Moines	861	5	99	29.02	29.93	−.09	72.4	+6.8	98	7	83	42	27	62	33	64	59	70	4.44	+0.8	11	6,102	s.	30	sw.	21	16	9	5	3.9	0.0	0.0
Dubuque	700	81	96	29.22	29.96	−.07	70.0	+6.0	96	16	79	44	27	61	32	62	58	73	6.67	+2.7	13	3,442	s.	16	nw.	26	12	8	10	4.9	0.0	0.0
Keokuk	614	64	78	29.33	29.96	−.04	74.0	+6.5	96	7	84	46	27	64	32	62	58	72	6.73	+2.9	13	4,139	s.	30	sw.	25	15	9	6	4.6	0.0	0.0
Cairo	358	87	93	29.65	30.02	−.03	77.0	+5.5	96	18	86	50	30	68	31	68	65	76	1.19	−1.7	5	4,295	s.	30	sw.	25	14	10	6	4.2	0.0	0.0
Peoria	609	11	48	29.35	30.02	−.02	73.0	+8.7	96	11	84	41	28	62	31	64	62	77	4.92	+0.9	11	3,155	s.	19	w.	14	18	7	5	3.3	0.0	0.0
Springfield, Ill	636	5	191	29.33	30.00	−.05	74.8	+7.2	97	16	86	48	28	64	32	65	61	71	3.15	−0.5	9	7,368	s.	30	s.	1	11	13	6	4.7	0.0	0.0
Hannibal	534	74	109	29.42	29.99	−.04	75.2	+7.5	95	15	85	46	28	65	31	----	----	----	3.72	−0.2	10	5,151	sw.	27	s.	22	14	10	6	4.1	0.0	0.0
St. Louis	568	265	303	29.40	30.00	−.04	76.9	+6.8	96	15	86	51	27	68	27	67	62	68	5.66	+2.2	8	7,470	sw.	36	sw.	21	20	7	3	3.2	0.0	0.0
Missouri Valley							73.6	+7.5										61	3.37	+0.2										3.7		
Columbia, Mo	784	6	84	29.16	29.98	−.05	75.2	+7.0	96	15	85	44	27	65	28	----	----	----	6.60	+2.3	7	4,317	s.	32	nw.	21	15	12	3	3.5	0.0	0.0
Kansas City	963	161	181	28.95	29.95	−.07	77.5	+8.6	102	5	88	49	27	67	30	65	60	63	5.12	+0.6	10	5,243	se.	31	sw.	25	16	9	5	3.3	0.0	0.0
St. Joseph	967	11	49	28.92	29.93	------	76.2	------	101	5	87	45	27	66	31	65	61	68	7.88	+4.0	9	5,188	se.	34	nw.	24	19	6	5	3.2	0.0	0.0
Springfield, Mo	1,324	98	104	28.62	30.00	−.03	75.2	+6.3	94	6	85	47	27	66	25	66	62	70	0.92	−2.6	7	6,088	s.	26	s.	21	22	7	1	1.8	0.0	0.0
Iola	984	11	50	28.93	29.95	−.06	79.0	+9.2	101	5	91	46	27	66	34	----	----	----	1.50	−3.4	5	3,944	s.	18	nw.	25	18	7	5	3.4	0.0	0.0
Topeka	987	92	107	------	------	------	77.2	+8.5	102	5	88	48	26	66	32	----	----	----	4.59	+0.8	8	6,580	sw.	28	sw.	20	16	7	7	3.3	0.0	0.0
Lincoln	1,189	11	81	28.65	29.89	−.10	74.6	+8.2	102	6	86	44	26	64	35	63	57	63	3.79	+0.8	10	6,929	s.	33	nw.	24	15	11	4	4.1	0.0	0.0
Omaha	1,105	115	122	28.75	29.91	−.09	73.7	+6.9	102	6	84	46	27	64	33	62	57	64	3.74	+0.5	10	4,561	s.	21	n.	17	17	8	5	3.6	0.0	0.0
Valentine	2,598	47	54	27.22	29.89	−.07	68.2	+5.7	106	9	82	36	26	54	45	55	47	57	0.98	−0.4	7	5,281	w.	31	nw.	25	9	13	8	4.8	0.0	0.0
Sioux City	1,135	94	164	28.69	29.88	−.10	71.8	+8.4	101	7	82	42	27	62	36	60	53	59	3.34	+0.3	7	8,172	s.	35	s.	11	12	7	11	4.8	0.0	0.0
Huron	1,306	59	74	28.50	29.88	−.08	68.6	+7.3	103	9	82	37	23	55	48	56	48	57	1.52	0.0	10	6,424	s.	33	sw.	11	14	13	3	3.7	0.0	0.0
Pierre	1,572	70	75	28.20	29.84	−.11	70.2	+6.4	108	9	84	38	23	57	45	55	45	51	1.43	+0.3	5	5,718	e.	31	nw.	29	16	8	6	4.0	0.0	0.0
Yankton	1,233	49	57	28.54	29.87	−.11	71.9	+7.9	103	7	83	44	26	61	43	----	----	----	2.32	−0.4	8	4,597	s.	24	s.	11	12	8	10	4.6	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, September, 1931*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Northern Slope							60.8	+3.4										53	1.17	0.0										4.5		
Billings	3,140	5	...	...	...	...	59.6	...	100	4	76	33	25	49	48	...	...	...	1.68	...	6	...	nw.	...	...	...	9	14	7	...	0.0	0.0
Havre	2,505	11	44	27.28	29.89	−0.05	58.7	+2.3	98	5	72	28	23	45	46	47	38	55	0.47	−0.8	7	5,452	sw.	31	sw.	11	10	15	5	4.9	0.0	0.0
Helena	4,110	87	112	25.77	29.92	−.05	56.6	0.0	90	4	68	32	23	46	37	46	38	56	1.18	−0.1	11	5,426	sw.	29	se.	5	6	10	14	6.1	T.	0.0
Kalispell	2,973	48	56	26.90	29.93	−.03	54.8	+1.3	90	3	66	29	23	44	38	47	40	64	2.89	+1.6	9	3,408	nw.	29	sw.	6	4	9	17	6.6	0.0	0.0
Miles City	2,371	48	55	27.38	29.89	−.06	64.4	+3.2	98	6	77	32	23	52	41	51	41	50	0.67	−0.4	3	3,851	s.	25	w.	11	18	9	3	3.5	0.0	0.0
Rapid City	3,259	50	58	26.54	29.88	−.08	67.6	+7.2	101	7	81	39	26	54	39	51	39	42	0.22	−1.0	4	4,673	w.	30	sw.	18	14	11	5	3.8	0.0	0.0
Cheyenne	6,088	84	101	24.04	29.89	−.07	61.8	+4.8	87	10	75	35	22	48	37	47	37	47	0.75	−0.4	5	7,053	w.	39	w.	25	17	7	6	3.8	0.0	0.0
Lander	5,372	60	68	24.63	29.89	−.07	59.8	+4.1	90	4	75	32	22	45	40	47	36	50	1.73	+0.8	5	3,620	sw.	35	sw.	10	20	7	3	2.5	2.1	0.0
Sheridan	3,790	10	47	26.04	29.89	...	60.3	...	97	4	76	34	27	44	47	48	40	58	2.08	+0.8	9	2,666	nw.	24	s.	5	14	10	6	4.3	0.0	0.0
Yellowstone Park	6,241	11	48	23.90	29.94	−.03	52.6	−0.8	83	4	66	25	23	39	39	41	32	55	1.30	0.0	8	4,928	sw.	31	sw.	12	12	8	10	5.1	0.8	0.0
North Platte	2,821	11	51	27.00	29.87	−.10	71.0	+8.9	105	5	85	36	26	57	47	56	47	53	0.41	−0.9	6	4,430	s.	23	s.	8	14	11	5	4.3	0.0	0.0
Middle Slope							76.0	+7.9										49	1.43	−0.6										3.3		
Denver	5,292	106	113	24.73	29.88	−.08	68.2	+5.3	94	9	81	39	23	55	34	51	38	40	0.22	−0.8	4	4,276	s.	24	s.	6	15	12	3	3.8	0.0	0.0
Pueblo	4,685	80	86	25.28	29.86	−.10	71.0	+6.4	96	9	85	43	27	57	40	53	41	41	0.72	0.0	3	4,434	nw.	28	nw.	12	13	14	3	4.1	0.0	0.0
Concordia	1,392	50	58	28.47	29.91	−.08	77.6	+9.3	107	5	89	45	26	67	34	63	56	56	1.96	−0.6	7	5,952	s.	31	nw.	24	18	8	4	3.5	0.0	0.0
Dodge City	2,509	88	100	27.38	29.91	−.07	77.8	+8.4	103	5	90	46	26	65	35	61	51	48	0.69	−1.2	5	10,266	s.	34	sw.	19	23	5	2	2.0	0.0	0.0
Wichita	1,358	139	158	28.52	29.91	−.09	79.4	+8.8	103	5	91	50	26	68	31	64	56	53	4.58	+1.5	4	9,269	s.	37	sw.	14	18	6	6	3.6	0.0	0.0
Oklahoma City	1,214	10	47	28.69	29.93	−.06	82.2	+9.4	103	5	94	54	26	71	29	67	60	56	0.43	−2.6	2	6,343	s.	24	nw.	1	21	9	0	3.0	0.0	0.0
Southern Slope							79.9	+6.4										52	0.14	−2.4												
Abilene	1,738	10	52	28.17	29.92	−.04	83.4	+8.1	100	5	95	63	30	72	27	66	57	49	0.09	−2.6	1	6,955	s.	29	s.	20	24	4	2	2.5	0.0	0.0
Amarillo	3,676	10	49	26.28	29.92	−.04	76.8	+7.5	97	5	90	54	22	64	32	60	52	50	0.51	−1.8	3	6,458	s.	20	se.	20	21	7	2	2.5	0.0	0.0
Del Rio	944	64	71	28.92	29.88	−.06	83.2	+4.0	98	25	93	66	30	73	26	70	64	60	T.	−3.0	0	6,388	se.	24	se.	12	17	13	0	3.3	0.0	0.0
Roswell	3,566	75	85	26.36	29.89	−.03	76.2	+5.9	95	4	90	50	22	63	41	61	53	51	0.02	−2.1	1	4,395	s.	26	s.	22	15	14	1	3.5	0.0	0.0
Southern Plateau							72.9	+2.2										54	1.36	+0.6										3.6		
El Paso	3,778	152	175	26.16	29.84	−.04	79.2	+5.3	96	9	90	60	21	68	30	63	55	50	1.10	−0.2	7	4,506	e.	31	sw.	13	14	15	1	3.8	0.0	0.0
Albuquerque	4,972	51	66	25.08	29.86	...	70.0	...	92	4	83	44	22	57	38	57	50	60	2.18	...	9	2,860	sw.	27	nw.	23	10	13	7	5.1	0.0	0.0
Santa Fe	7,013	38	53	23.34	29.89	−.04	63.4	+2.5	85	4	74	38	21	52	31	52	46	64	4.59	+3.1	16	3,261	e.	21	ne.	5	7	17	6	5.3	0.0	0.0
Flagstaff	6,907	10	59	23.41	29.85	−.04	58.4	+2.9	80	6	72	28	21	45	41	49	...	65	2.08	...	7	4,960	sw.	35	sw.	19	14	9	7	...	0.0	0.0
Phoenix	1,108	10	107	28.64	29.76	−.05	85.9	+3.2	107	7	99	58	21	73	38	66	55	41	0.23	−0.5	3	2,952	e.	24	sw.	19	21	6	3	2.3	0.0	0.0
Yuma	141	9	54	29.62	29.76	−.02	83.6	−0.1	108	6	99	58	11	69	41	67	57	49	0.74	+0.4	4	2,596	w.	21	n.	20	26	3	1	1.5	0.0	0.0
Independence	3,957	6	27	25.91	29.89	+.03	67.4	−0.6	92	2	83	42	21	52	40	49	...	...	0.12	0.0	1	...	s.	...	...	...	...	26	3	1	...	0.0	0.0
Middle Plateau							62.9	+1.0										41	0.76	+0.1										2.5		
Reno	4,532	74	81	25.44	29.89	−.06	60.2	+0.5	95	3	76	32	23	45	42	46	32	42	0.63	+0.4	3	3,945	sw.	40	w.	28	20	8	2	2.4	T.	0.0
Tonopah	6,090	12	20	...	...	...	61.0	...	83	2	72	35	23	50	32	46	32	39	0.96	...	2	...	se.	...	...	...	...	...	...	...	0.0	0.0
Winnemucca	4,344	18	56	25.59	29.94	+.01	58.8	−0.4	97	3	76	28	24	41	50	44	30	41	0.33	−0.1	6	4,038	sw.	26	w.	18	19	8	3	2.9	0.0	0.0
Modena	5,473	10	43	24.60	29.86	−.06	60.8	+0.8	85	2	78	30	25	44	45	45	29	38	0.39	−0.4	1	7,779	sw.	41	sw.	8	24	4	2	1.8	0.0	0.0
Salt Lake City	4,360	163	203	25.58	29.88	−.07	65.6	+1.2	91	7	77	42	24	54	30	50	36	38	0.56	−0.4	6	5,429	se.	34	nw.	15	21	6	3	2.8	0.0	0.0
Grand Junction	4,602	60	68	25.35	29.88	−.07	69.0	+2.8	93	6	82	44	25	56	36	53	42	47	1.87	+1.0	9	4,274	se.	33	s.	6	20	8	2	2.7	0.0	0.0
Northern Plateau							61.8	+1.1										48	0.76	0.0										4.4		
Baker	3,471	48	53	26.43	29.98	−.01	55.8	−0.2	94	3	70	30	23	41	39	45	36	52	0.63	−0.1	4	3,498	se.	23	sw.	6	12	12	6	4.4	0.0	0.0
Boise	2,739	79	87	27.11	29.94	−.03	62.5	+0.6	101	3	76	40	25	49	37	49	37	44	0.60	+0.1	4	2,984	nw.	19	nw.	8	13	11	6	4.2	0.0	0.0
Lewiston	757	40	48	29.13	29.93	−.05	64.5	+1.7	98	3	78	38	23	51	41	...	...	...	0.73	−0.2	7	1,987	e.	27	w.	6	15	5	10	4.5	0.0	0.0
Pocatello	4,477	60	68	25.45	29.90	−.06	61.3	+1.1	92	4	74	36	22	48	38	47	34	44	1.11	+0.3	7	5,322	se.	36	s.	4	12	12	6	4.1	T.	0.0
Pasco	416	5	33	...	...	...	64.2	...	98	3	80	35	7	49	47	...	...	45	0.04	...	2	5,394	sw.	...	...	...	11	13	6	...	0.0	0.0
Spokane	1,929	101	110	27.91	29.94	−.04	60.6	+1.4	91	3	72	40	23	49	36	50	40	55	1.05	+0.2	6	3,467	s.	24	nw.	20	7	13	10	5.3	0.0	0.0
Walla Walla	991	57	65	28.87	29.94	−.06	65.2	+1.4	95	3	76	38	23	54	35	52	42	46	0.98	0.0	5	2,708	s.	21	w.	18	12	13	5	4.3	0.0	0.0
Yakima	1,076	58	67	28.80	29.94	...	62.6	+1.5	95	3	76	38	24	50	39	51	42	52	0.23	−0.3	4	3,132	nw.	23	w.	20	15	8	7	4.1	0.0	0.0
North Pacific Coast Region							59.3	+1.0										74	3.02	+0.9										6.0		
North Head	211	11	56	29.80	30.02	−.01	57.0	+0.5	70	22	61	49	26	53	17	55	53	88	5.15	+2.2	16	9,227	n.	54	s.	29	7	10	13	6.2	0.0	0.0
Port Angeles	29	8	53	...	30.02	...	55.5	...	71	23	62	41	24	49	29	...	...	...	1.50	0.0	13	2,839	s.	26	w.	20	5	11	14	...	0.0	0.0
Seattle	125	215	250	29.86	29.99	−.02	59.2	+1.1	78	3	65	47	26	53	20	54	50	75	2.97	+1.2	11	4,895	s.	31	sw.	6	5	6	19	7.0	0.0	0.0
Tacoma	194	172	201	29.80	30.00	−.02	59.4	+2.1	81	3	66	43	22	52	28	...	...	...	2.67	+0.6	10	4,625	s.	33	sw.	6	2	10	18	7.5	0.0	0.0
Tatoosh Island	86	9	53	29.88	29.98	−.03	55.4	+2.4	72	23	59	48	8	52	24	53	52	89	7.97	+3.3	19	7,583	s.	42	s.	4	3	3	24	7.8	0.0	0.0
Medford	1,329	29	58	28.55	29.94	...	62.9	...	101	2	79	36	24	47	49	51	41	55	1.23	+0.7	6	3,170	nw.	28	nw.	6	17	8	5	3.2	0.0	0.0
Portland, Oreg	153	68	106	29.84	30.00	−.03	62.8	+1.1	89	4	72	45	24	54	28	56	51	70	2.10	+0.1	10	3,241	nw.	18	ne.	22	7	7	16	6.5	0.0	0.0
Roseburg	510	75	99	29.44	29.99	−.03	61.9	−1.0	91	2	75	38	24	49	42	53	46	64	0.57	−0.7	7	2,476	n.	20	n.	22	14	11	5	3.7	0.0	0.0
Middle Pacific Coast Region							64.5	−0.3										57	0.13	−0.5										2.8		
Eureka	62	73	89	29.94	30.01	.00	55.6	−0.3	68	23	61	46	22	51	20	53	51	85	0.54	−0.5	5	3,279	nw.	32	n.	22	12	8	10	4.9	0.0	0.0
Red Bluff	330	5	58	29.52	29.87	−.06	72.0	−1.1	105	1	86	46	28	58	42	55	39	37	0.09	−0.7	1	4,015	s.	24	n.	22	22	7	1	2.3	0.0	0.0
Redding	722	20	34	...	...	...	68.6	...	103	1	78	49	28	60	34	...	...	32	T.	...	0	5,406	nw.	...	...	...	20	9	1	...	0.0	0.0
Sacramento	69	106	117	29.81	29.88	−.01	67.6	−1.7	98	13	82	47	9	53	42	56	48	56	T.	−0.4	0	5,338	s.	26	nw.	22	28	2	0	0.7	0.0	0.0
San Francisco	155	208	243	29.76	29.93	−.01	62.8	+1.9	86	30	70	52	1	55	30	56	51	73	T.	−0.4	0	4,882	w.	24	w.	17	12	17	1	3.6	0.0	0.0
San Jose	141	12	110	29.78	29.93	...	64.6	−0.1	91	21	78	45	24	52	39	...	...	...	T.	−0.4	0	3,826	nw.	22	sw.	14	19	8	3	2.6	0.0	0.0
South Pacific Coast Region							71.1	+1.3										60	0.10	−0.1										2.2		
Fresno	327	89	98	29.52	29.87	.00	72.2	−1.2	101	2	87	50	24	58	37	56	43	42	0.05	−0.2	1	4,457	nw.	24	nw.	7	24	6	0	1.1	0.0	0.0
Los Angeles	338	159	191	29.52	29.88	.00	71.5	+2.5	93	5	81	56	13	62	32	60	54	62	0.24	+0.1	2	2,932	w.	13	w.	25	22	5	3	2.2	0.0	0.0
San Diego	87	62	70	29.77	29.86	−.03	69.7	+2.6	86	21	76	59	11	64	24	64	61	76	T.	−0.1	0	3,959	nw.	20	w.	5	19	8	3	3.3	0.0	0.0
West Indies																																
San Juan, P. I	82	9	54	29.84	29.93	...	80.6	+0.1	91	11	85	72	3	76	17	...	...	...	10.60	+4.7	22	6,648	e.	90	nw.	10	1	17	12	6.4	0.0	0.0
Panama Canal																																
Balboa Heights	118	6	97	...	[1] 29.83	...	79.6	−0.2	90	25	85	72	13	74	17	...	...	[1] 87	11.09	+3.0	21	3,265	nw.	24	nw.	27	0	11	19	7.9	0.0	0.0
Cristobal	36	6	97	...	[1] 29.83	...	81.6	+1.2	91	3	87	75	13	76	16	76	75	[1] 83	8.24	−4.1	21	3,886	se.	24	nw.	28	1	9	20	7.8	0.0	0.0
Alaska																																
Fairbanks	455	11	44	...	[2] 29.84	...	43.4	...	63	2	50	26	26	36	27	...	...	80	1.48	...	16	2,525	w.	14	sw.	22	1	4	25	...	T.	0.0
Juneau	80	11	50	[2] 29.77	[2] 29.77	...	50.8	...	69	7	57	36	16	45	23	48	45	84	9.37	...	21	3,183	s.	28	e.	30	4	8	18	7.6	0.0	0.0
Hawaiian Islands																																
Honolulu	38	86	100	[1] 29.95	[2] 29.99	...	77.8	−0.4	84	21	82	71	7	74	12	72	69	77	2.69	+1.4	16	6,598	e.	25	e.	25	5	22	3	5.6	0.0	0.0

[1] Observations taken bihourly.

[2] Pressure not reduced to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, September, 1931*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*Inches*	*Inches*	*Inches*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*Inches*	*Inches*	*Inches*
Cape Race, N. F	99				55.3		63.2	47.5	75	34	4.23		0.0
Sydney, C. B. I	48	29.85	29.90	−0.11	57.8	+1.3	65.7	50.0	80	38	4.06	+0.78	0.0
Halifax, N. S	88	29.81	29.91	−.13	58.6	+1.0	66.6	50.6	82	41	6.95	+3.24	0.0
Yarmouth, N. S	65	29.83	29.90	−.15	57.7	+1.6	64.2	51.2	76	40	4.78	+1.17	0.0
Charlottetown, P. E. I	38	29.80	29.84	−.17	56.9	−0.4	62.7	51.1	76	42	3.76	+0.36	0.0
Chatham, N. B	28	29.80	29.83	−.17	55.4	0.0	64.2	46.7	85	33	3.86	+1.15	0.0
Father Point, Que	20	29.88	29.90	−.08	50.0	−0.4	57.4	42.7	70	31	4.83	+1.70	0.0
Quebec, Que	296	29.63	29.95	−.06	56.2	+1.1	63.4	49.0	83	35	6.51	+2.84	0.0
Doucet, Que	1,236				51.6		63.3	40.0	87	20	4.52		0.0
Montreal, Que	187	29.73	29.93	−.11	61.7	+3.3	69.2	54.2	90	42	7.44	+4.14	0.0
Ottawa, Ont	236	29.70	29.96	−.08	64.3	+6.9	75.7	53.0	102	39	5.70	+3.01	0.0
Kingston, Ont	285	29.67	29.98	−.06	64.4	+4.4	72.1	56.7	88	40	4.94	+2.14	0.0
Toronto, Ont	379	29.58	29.97	−.09	65.9	+6.9	75.4	56.4	96	42	2.18	−1.07	0.0
Cochrane, Ont	930				55.9		64.6	47.3	91	32	2.95		0.0
White River, Ont	1,244	28.62	29.92	−.06	55.5	+5.2	67.4	43.7	91	26	3.59	+0.82	0.0
London, Ont	808				65.8		77.1	54.5	95	32	3.57		0.0
Southampton, Ont	656	29.29	30.00	−.05	63.3	+5.8	73.3	53.4	92	36	4.20	+1.26	0.0
Parry Sound, Ont	688	28.28	29.96	−.07	61.7	+5.7	70.5	52.9	89	37	5.15	+1.48	0.0
Port Arthur, Ont	644	29.21	29.92	−.06	58.5	+6.3	66.8	50.2	78	41	5.46	+1.98	0.0
Winnipeg, Man	760	29.02	29.84	−.10	59.9	+7.4	70.3	49.6	96	33	3.23	+1.20	0.0
Minnedosa, Man	1,690	28.06	29.85	−.09	55.0	+4.5	65.9	44.1	93	29	1.54	+0.18	0.0
Le Pas, Man	860				51.6		60.5	42.8	83	32	5.09		0.0
Qu'Appelle, Sask	2,115	27.61	29.83	−.09	54.1	+3.0	65.3	42.9	90	31	1.25	−0.08	0.0
Moose Jaw, Sask	1,759				56.4		69.5	43.3	95	30	1.81		0.0
Swift Current, Sask	2,392	27.31	29.80	−.12	55.5	+2.4	69.7	41.2	96	32	2.35	+1.13	0.0
Medicine Hat, Alb	2,365	27.40	29.87	−.05	55.7	+0.7	67.6	43.8	92	30	1.76	+0.58	0.0
Calgary, Alb	3,428	26.21	29.86	−.06	50.8	+1.0	62.2	39.5	82	29	1.71	+0.35	0.0
Banff, Alb	4,521	25.32	29.89	−.04	47.2	+1.4	58.0	36.4	73	24	2.17	+0.50	0.0
Prince Albert, Sask	1,450	28.31	29.88	−.02	52.7	+4.3	62.6	42.9	84	30	2.66	+1.38	0.0
Battleford, Sask	1,592	28.11	29.83	−.07	52.7	+0.9	64.2	41.1	89	29	3.37	+2.12	0.0
Edmonton, Alb	2,150	27.55	29.83	−.07	50.2	+0.9	61.0	39.4	73	27	0.56	−0.77	0.0
Kamloops, B. C	1,262	28.62	29.90	−.07	57.0	−0.4	65.0	49.1	82	36	0.80	−0.45	0.0
Victoria, B. C	230	29.73	29.98	−.03	56.0	+1.2	61.5	50.5	69	46	2.28	+0.12	0.0
Barkerville, B. C	4,180												
Estevan Point, B. C	20				53.9		59.6	48.3	68	42	12.21		0.0
Prince Rupert, B. C	170				53.4		59.1	47.8	64	42	8.10		0.0
Hamilton, Ber	151	29.96	30.12	+.05	80.8	+3.4	88.0	73.6	93	70	2.46	−4.05	0.0
LATE REPORTS, AUGUST, 1931													
Sydney, C. B. I	48	29.96	30.01	+0.06	65.1	+1.8	74.0	56.2	85	46	6.52	+2.90	0.0
Halifax, N. S	88	29.89	29.99	+.03	66.8	+3.2	76.7	56.9	86	49	4.60	+0.25	0.0
Yarmouth, N. S	65	29.88	29.95	−.02	63.5	+3.3	71.8	55.2	79	48	3.60	−0.02	0.0
Charlottetown, P. E. I	38	29.88	29.92	−.02	66.4	+2.1	73.5	59.4	81	51	2.79	−0.95	0.0
Chatham, N. B	28	29.87	29.90	−.03	63.7	+0.5	74.0	53.4	86	44	3.38	−0.66	0.0
Father Point, Que	20	29.93	29.95	+.04	57.1	+1.5	65.0	49.2	76	44	1.92	−1.13	0.0
Doucet, Que	1,236				55.5		70.1	40.9	85	28	2.29		0.0
Kingston, Ont	285	29.71	30.01	+.03	69.1	+2.1	77.0	61.2	88	52	1.19	−1.19	0.0
Southampton, Ont	656	29.31	30.02	+.03	66.4	+2.6	76.0	56.8	89	44	1.96	−0.29	0.0
Medicine Hat, Alb	2,365	27.50	29.94	+.02	67.0	+1.3	82.3	51.8	97	36	0.22	−1.45	0.0
Calgary, Alb	3,428	26.34	29.96	+.04	61.3	+1.9	75.8	46.8	90	38	0.46	−1.68	0.0
Banff, Alb	4,521	25.45	29.98	+.07	57.0	+0.7	73.1	40.8	88	33	1.61	−0.92	0.0
Edmonton, Alb	2,150	27.70	29.96	+.04	60.1	+1.3	71.3	48.9	82	38	4.20	+2.07	0.0
Kamloops, B. C	1,262	28.69	29.95	+.04	68.8	+0.2	81.7	55.9	96	48	0.70	−0.39	0.0
Estevan Point, B. C	20				56.5		62.7	50.3	73	45	3.07		0.0
Prince Rupert, B. C	170				57.7		63.4	52.1	70	48	5.70		0.0
Hamilton, Ber	151	30.02	30.18	+.08	82.4	+2.8	89.8	75.1	95	69	3.76	−2.32	0.0

TABLE 2.—Data furnished by the Canadian Meteorological Service, September, 1931

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Mean maximum	Temperature of the air: Mean minimum	Temperature of the air: Highest	Temperature of the air: Lowest	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Total snowfall
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

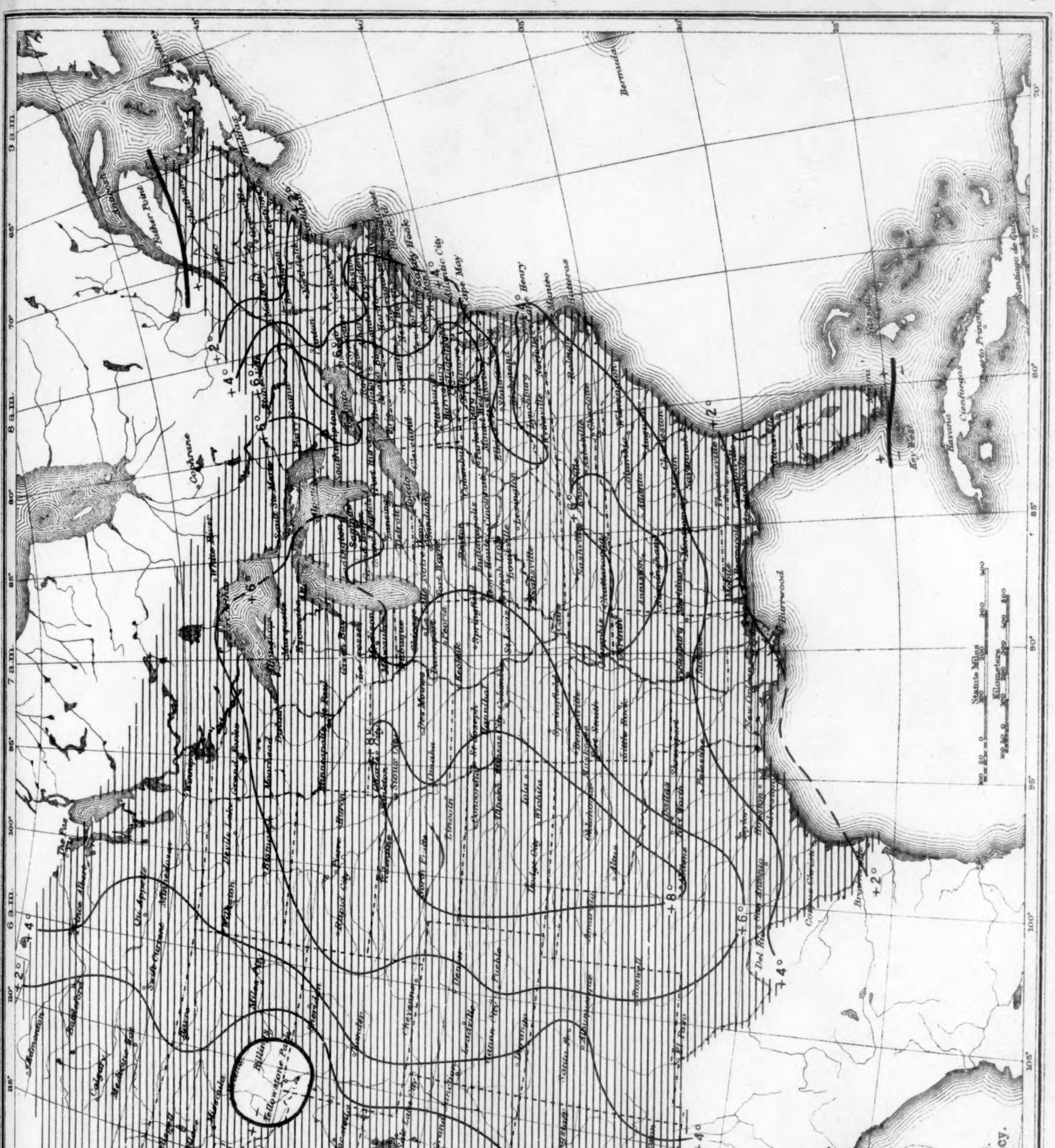
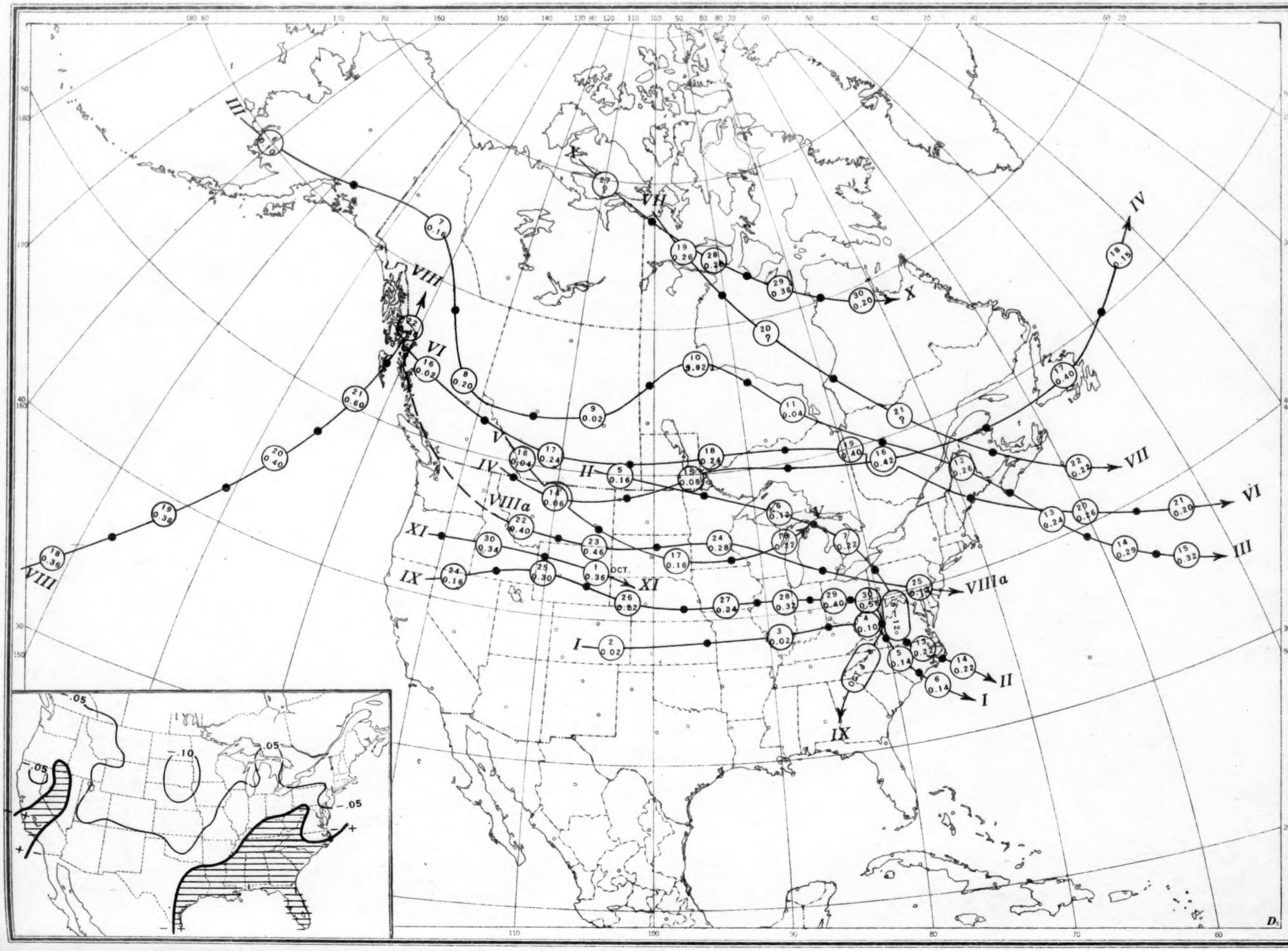

Shaded portions show excess (+).
Unshaded portions show deficiency (−).
Lines show amount of excess or deficiency.
Statute Miles
Kilometers
Bermuda
Key West
Havana
Cienfuegos
Cochrane
Edmonton
The Pas
Yellowstone Park
Winnipeg
+2°
+4°
+6°
+8°

Chart II. Tracks of Centers of Anticyclones, September, 1931. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by G. E. Dunn)



Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

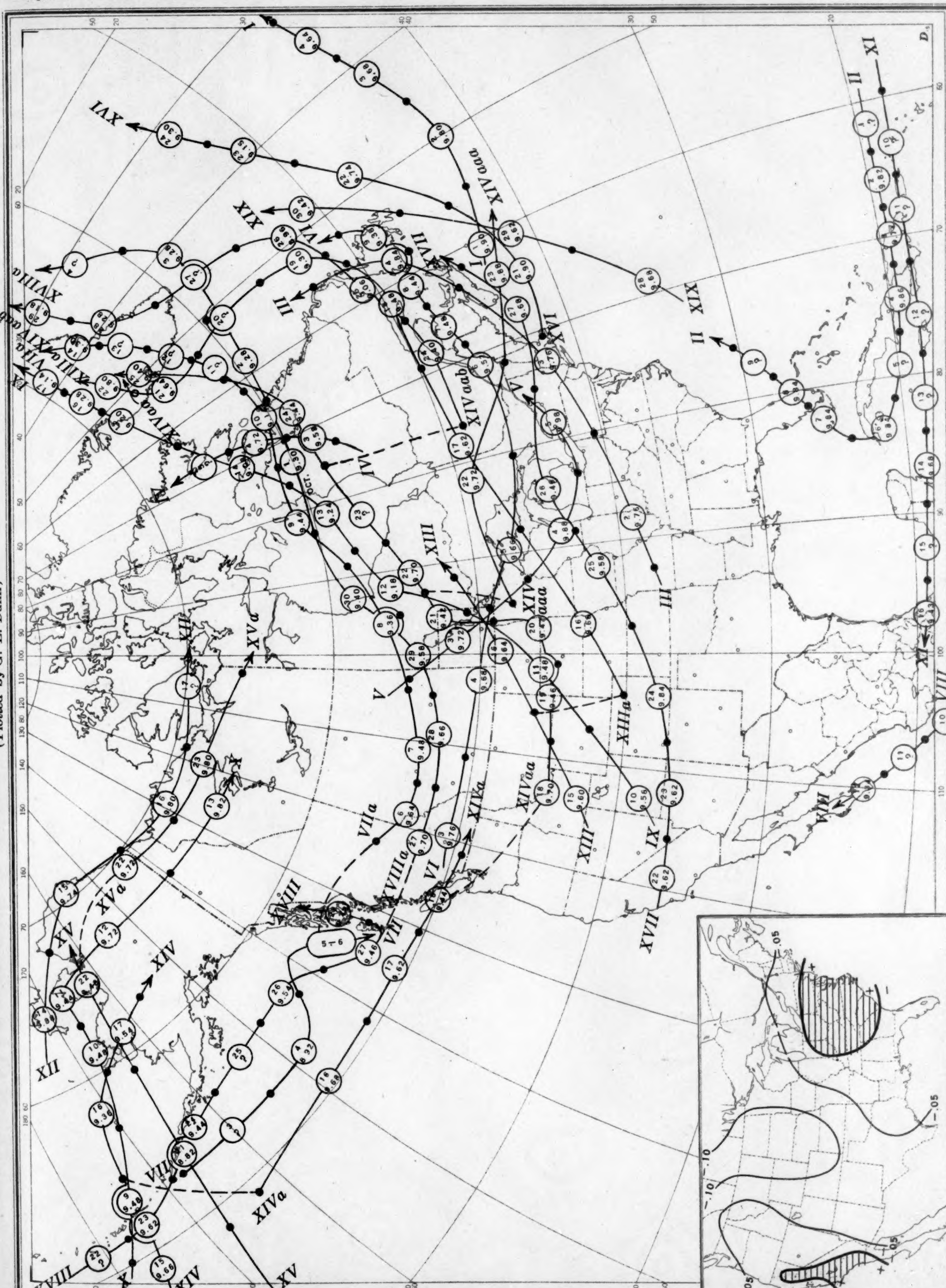
Chart III. Tracks of Centers of Cyclones, September, 1931. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by G. E. Dunn)

Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

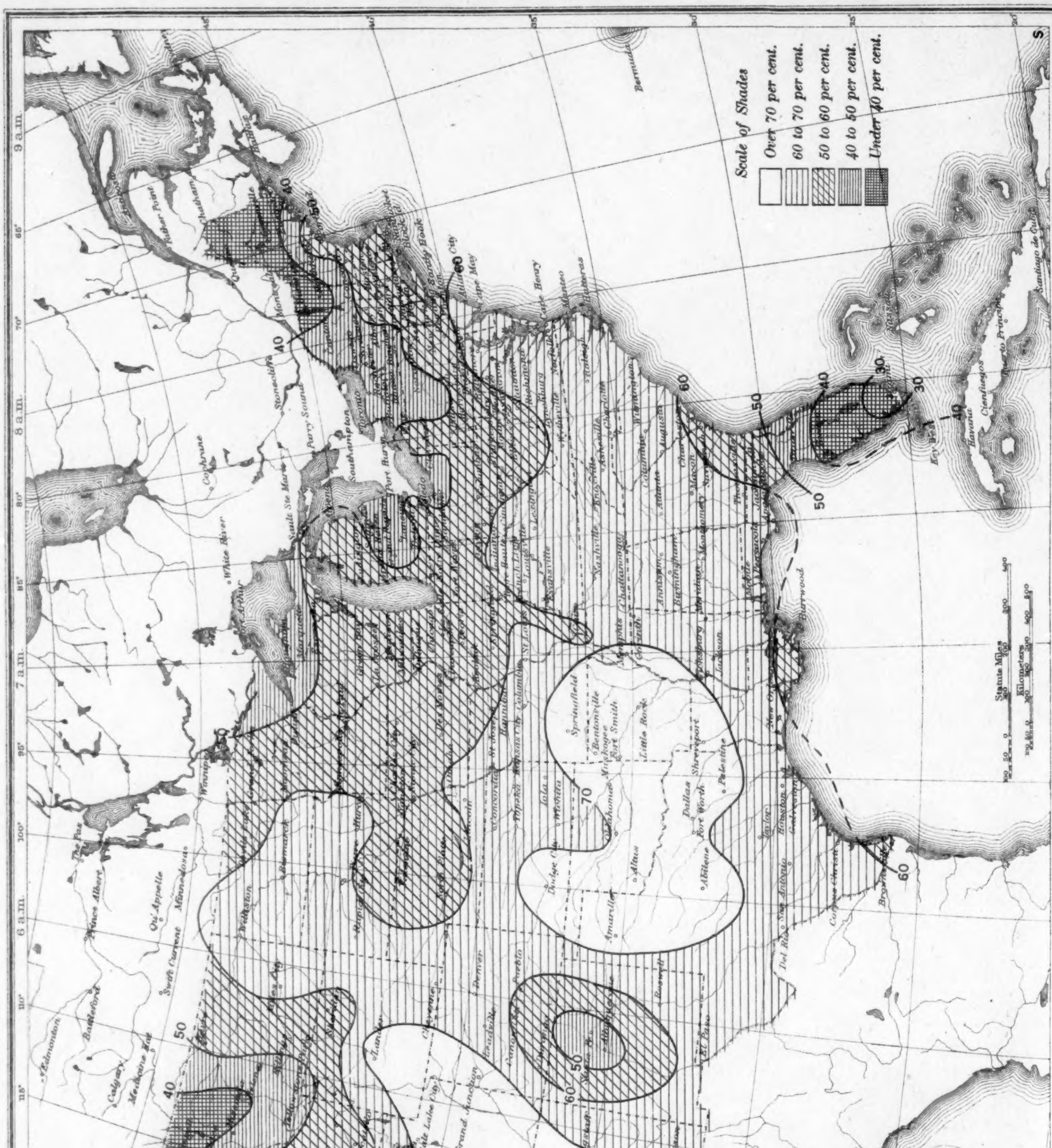
Chart III. Tracks of Centers of Cyclones, September, 1931. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by G. E. Dunn)



Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, September, 1931



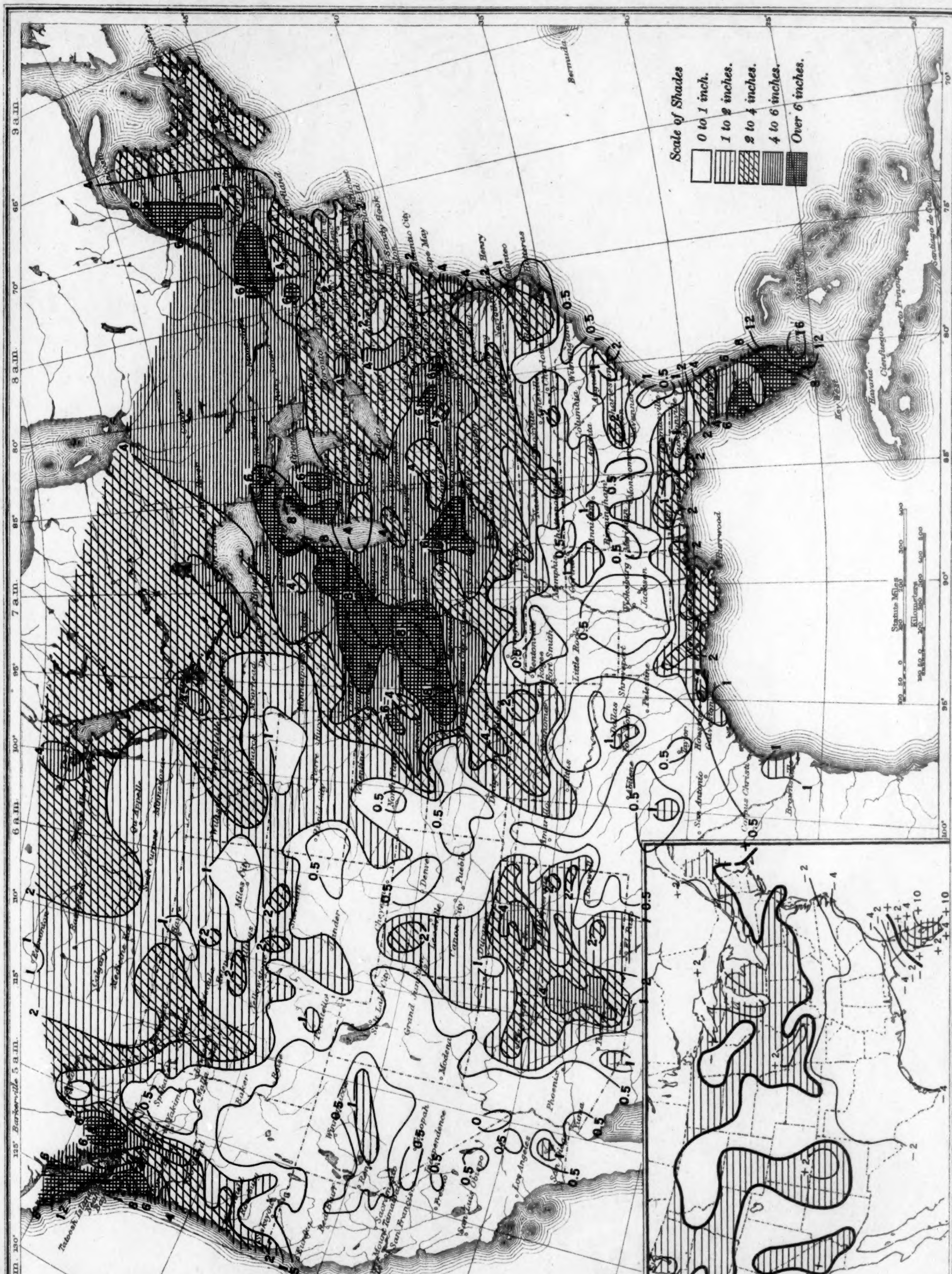


Chart V. Total Precipitation, Inches, September, 1931. (Inset) Departure of Precipitation from Normal

Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, September, 1931

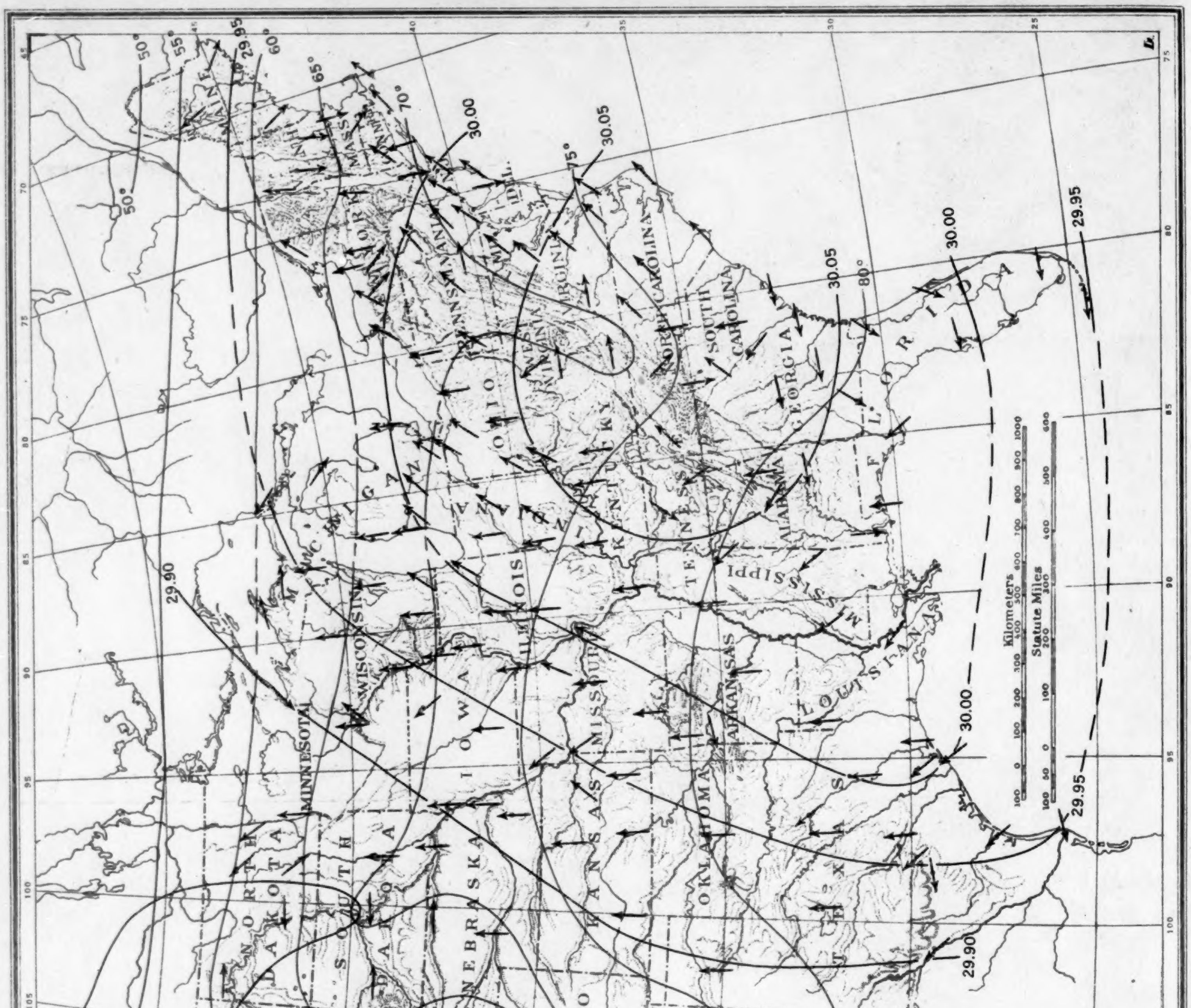


Chart VIII. Weather Map of North Atlantic Ocean, September 8, 1931
(Plotted from the Weather Bureau Northern Hemisphere Chart)

Chart VIII. Weather Map of North Atlantic Ocean, September 8, 1931
(Plotted from the Weather Bureau Northern Hemisphere Chart)

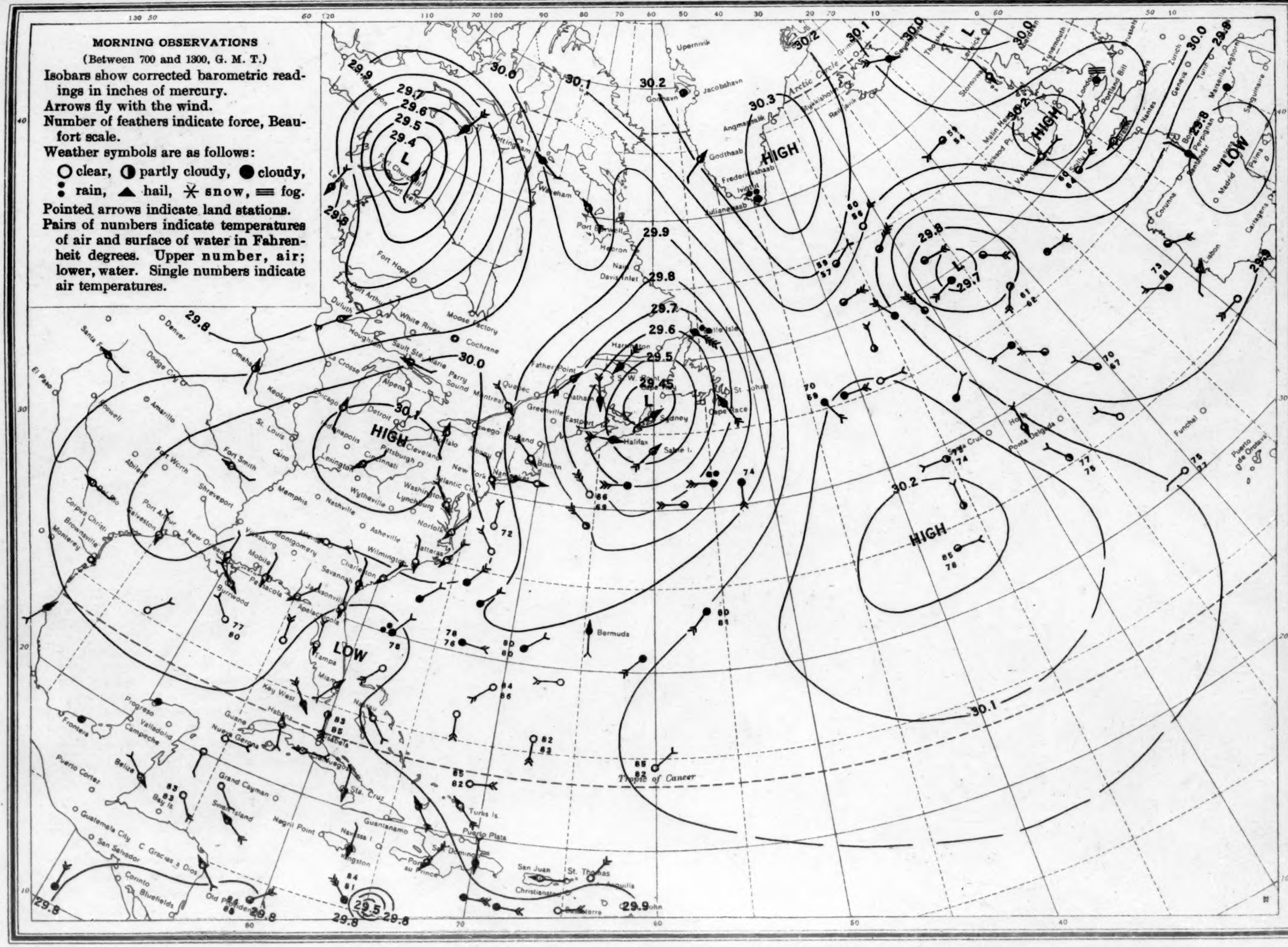


Chart IX. Weather Map of North Atlantic Ocean, September 10, 1931
(Plotted from the Weather Bureau Northern Hemisphere Chart)

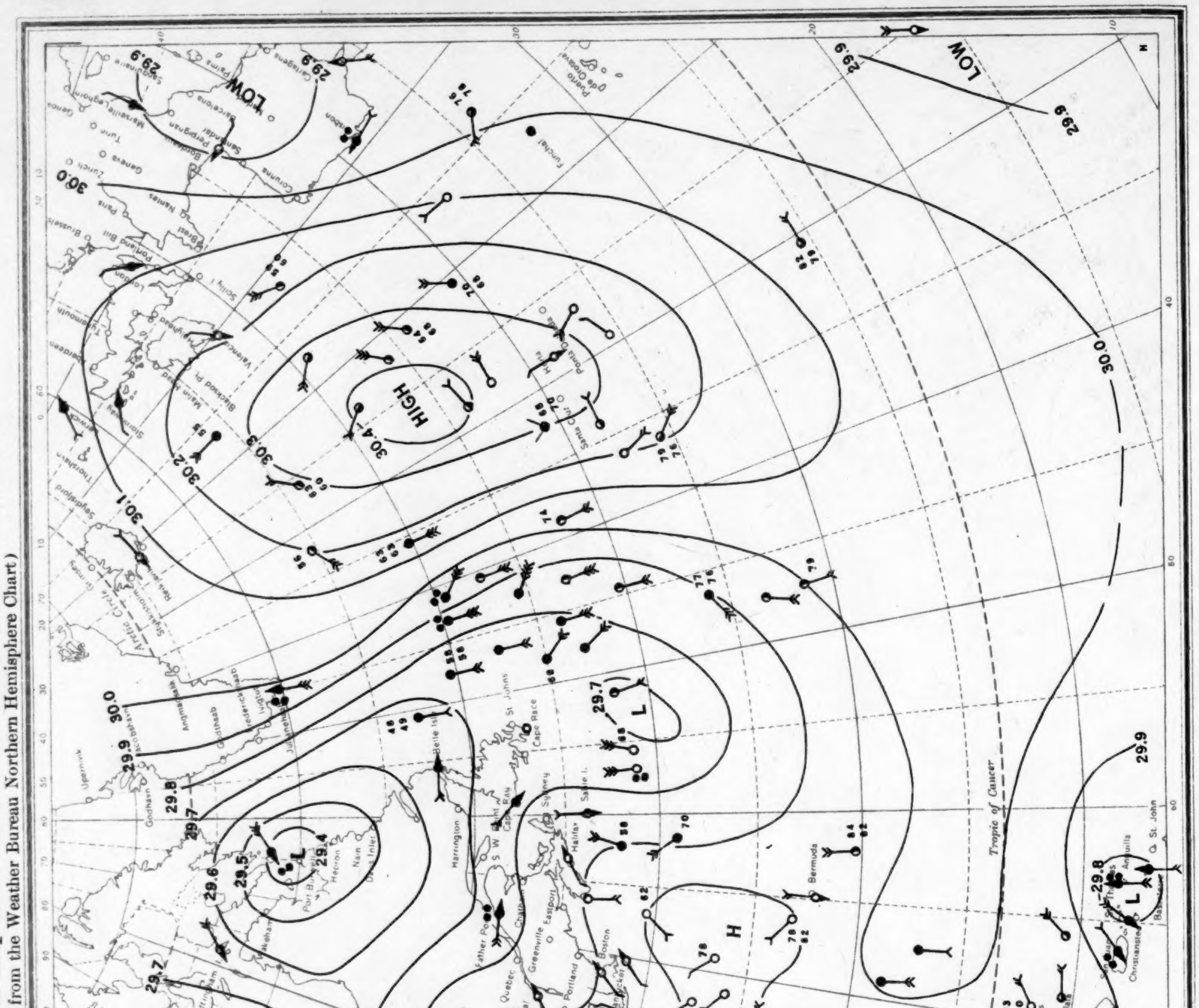


Chart X. Weather Map of North Atlantic Ocean, September 14, 1931
(Plotted from the Weather Bureau Northern Hemisphere Chart)

Chart X. Weather Map of North Atlantic Ocean, September 14, 1931
(Plotted from the Weather Bureau Northern Hemisphere Chart)

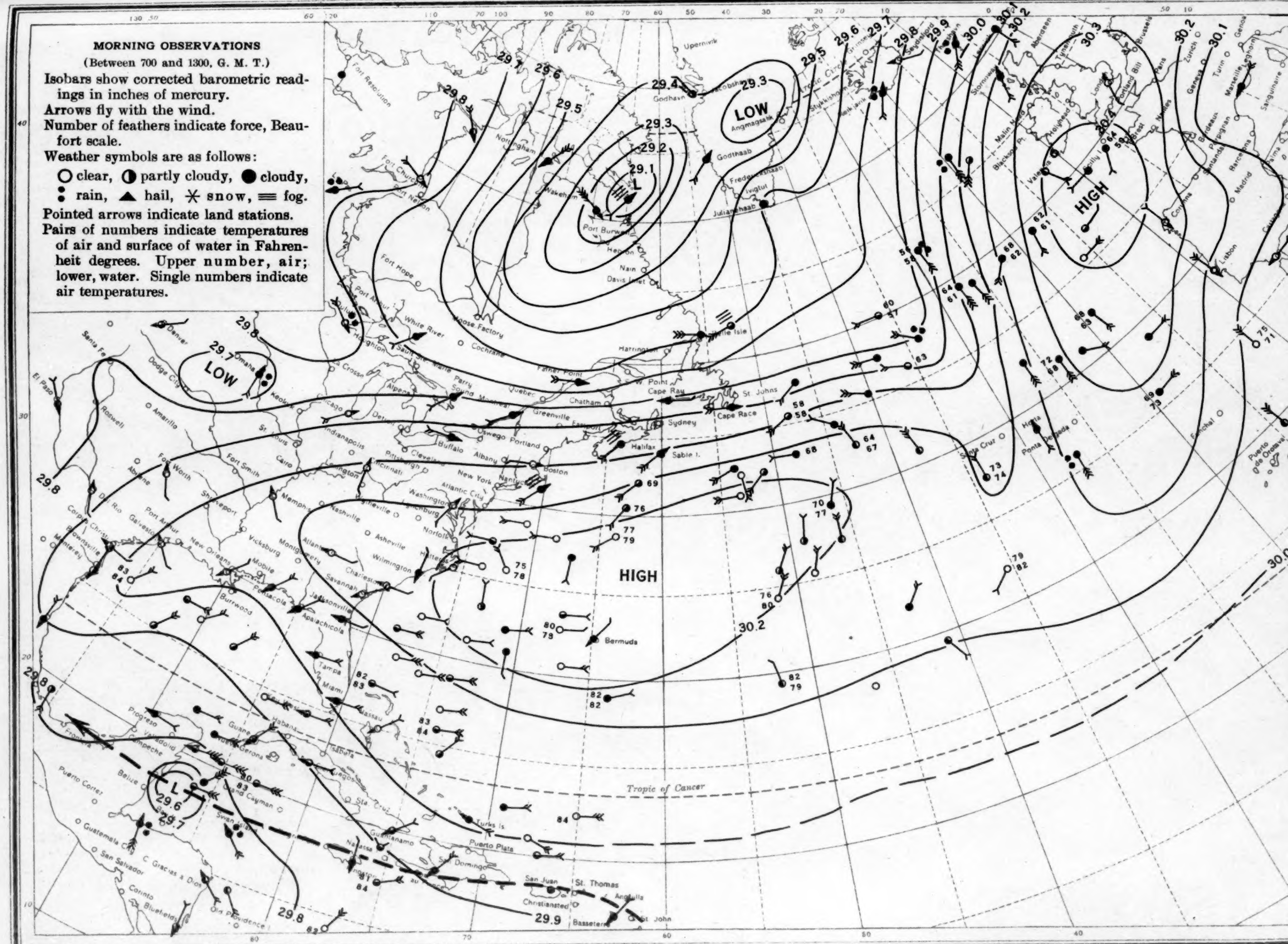


Chart XI. Weather Map of North Atlantic Ocean, September 23, 1931

(Plotted from the Weather Bureau Northern Hemisphere Chart)